DOCUMENT RESUME

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IDENTIFIERS	Military Curriculum Project

ABSTRACT

This course contains materials for both classroom (and shop) instruction and independent study in the skills needed by construction electricians. It was adapted from military curriculum materials for use in vocational education. Students completing the course will be able to perform apprentice duties pertaining to the installation of overhead electrical distribution systems up to 5,000 volts, operate power plants up to 200 kilowatts singly or in parallel, install interior wiring systems with associated electric devices and equipment, and perform electrical tests and maintenance on 115/230 volt circuits. Basic electricity and electronics is a prerequisite for this course. The course material, which covers 205 hours of instruction, is organized into four units: introduction, pole climbing indoctrination, interior electrician, and power generation and distribution. The course contains both teacher and student materials. The teacher materials include the "Curriculum Outline for Construction Electrician, Class A1" and two instructor's guides. The curriculum outline contains an introduction to the course; outline of instruction; outline of training objectives; and lists of texts, references, tools, equipment, materials, training aids and devices, and a master schedule. The instructor guides contain the lesson outlines. The student materials include four texts plus information sheets, job sheets, and drawings. (KC)

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ED217199

Military Curriculum Materials for Vocational and Technical Education

Construction Electrician

3-16

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THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY
1960 KENNY ROAD • COLUMBUS, OHIO 43210

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
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The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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Military Curriculum Materials for Vocational and Technical Education

Information and Field
Services Division

The National Center for Research
in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

CONSTRUCTION ELECTRICIAN

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Tools & Their Uses - Training Manual	Page 609
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CONSTRUCTION ELECTRICIAN

Classroom Course

3-16

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Developed by
United States Navy

Development and Review Dates
June 1975

D.O.T. No.:
824.281

Occupational Area:
Building and Construction

Target Audiences:
Grades 12-adult

Print Pages:
550

Cost:
$11.00

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Unit 1.1 – Introduction	•						•			★	•	
Unit 1.2 – Pole Climbing Indoctrination	•	•			•	★	•	•		★	•	•
Unit 1.3 – Interior Electrician	•	•		•	•	★	•	•		★	•	•
Unit 2.1 – Power Generation and Distribution	•			•	•	★	•	•		★	•	•

★ Materials are recommended but not provided.

THE CENTER FOR VOCATIONAL EDUCATION

Expires July 1, 1978

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Course Description

Students completing this course will be able to perform apprentice duties pertaining to the installation of overhead electrical distribution systems up to 5,000 volts, operate power plants up to 200 KW singly or in parallel, install interior wiring systems with associated electric devices and equipment, and perform electrical tests and maintenance on 115/230 volt circuits. Basic electricity and electronics is a prerequisite for this course.

This course contains materials for 205 hours of instruction for both classroom and shop use. The course materials are divided into four units. The first section of Unit 1.1 and all of Unit 2.2 were deleted because they deal with specific military procedures, organization and forms. The remaining sections are acceptable for use in vocational education. These sections include the following:

Unit 1.1 — **Introduction**

1.1.2 — Study Techniques (1 hour classroom)
1.1.3 — Safety Techniques (1 hour classroom)

Unit 1.2 — **Pole Climbing Indoctrination**

1.2.1 — Pole Climbing Equipment and Techniques (2 hours classroom, 9 hours practical)
1.2.2 — Pole Climbing Practice to Qualify (12 hours practical)

Unit 1.3 — **Interior Electrician**

1.3.1 — Boxes, Fittings and Electrical Devices (7 hours classroom)
1.3.2 — Basic Circuits and Blueprints (7 hours classroom, 1 hour practical)
1.3.3 — Conductors, Splices and Connectors (1 hour classroom, 1 hour practical)
1.3.4 — Code Studies (5 hours classroom)
1.3.5 — Conduit Installation (2 hours classroom, 12 hours practical)
1.3.6 — Non-Metallic Sheathed Cable (2 hours classroom)
1.3.7 — Service Entrances (2 hours classroom)
1.3.8 — Light Fixtures (2 hours classroom)
1.3.9 — Temporary Wiring (1 hour classroom, 5 hours practical)
1.3.10 — Hand Tools and Test Equipment (2 hours classroom, 3 hours practical)
1.3.11 — Motors, Motor Controllers and Circuits (6 hours classroom)
1.3.12 — Cubicle Wiring (1 hour classroom, 26 hours practical)
1.3.13 — Maintenance and Trouble Shooting (2 hours classroom, 7 hours practical)

Unit 2.1 — **Power Generation and Distribution**

2.1.1 — Tying Knots (2 hours classroom, 4 hours practical)
2.1.2 — Framing Poles (1 hour classroom, 5 hours practical)
2.1.3 — Erecting and Setting Poles (2 hours classroom, 7 hours practical)
2.1.4 — Mounting Crossarms, Pins and Insulators (2 hours classroom, 13 hours practical)
2.1.5 — Guying Poles (2 hours classroom, 7 hours practical)
2.1.6 — Stringing Primary Line Conductors (1 hour classroom, 10 hours practical)
2.1.7 — Transformers and Protective Equipment (1 hour classroom, 5 hours practical)
2.1.8 — Stringing Secondary Mains (1 hour classroom, 6 hours practical)
2.1.9 — Transformer Connections (3 hours classroom, 4 hours practical)
2.1.10 — Pole Top Rescue (1 hour classroom, 6 hours practical)
2.1.11 — Power Plants (2 hours classroom, 7 hours practical)
2.1.12 — Systems Testing (1 hour classroom, 2 hours practical)
2.1.13 — Disassemble Pole Line (1 hour classroom, 10 hours practical)

The course contains both teacher and student materials. The teacher materials include the *Curriculum Outline for Construction Electrician, Class A 1* and two instructor's guides. The curriculum outline contains an introduction to the course; outline of instruction; outline of training objectives; and lists of texts, references, tools, equipment, materials, training aids and devices, and a master schedule. The instructor guides contain the lesson outlines. The student materials include four texts plus information sheets, job sheets, and drawings.

Three Navy and three commercial texts are required but are not included. One Navy and two commercial references are suggested. The following films are suggested for use but are not provided:

CLI-001	Climbing with Confidence
HOW-001	How Distribution Transformers are Made
ITS-001	It's CSP for Me
PO L-001	Pole Top Rescue and Closed Heart Massage
U.S. Navy	
MA-5741-A2	Erecting Large Poles
MA-2564	Installation of Crossarms
MS-9559	First Aid, Part IV, Resuscitation, Mouth-to-Mouth, Nose-to-Nose
MC-8317	Lifeline of the Lineman
U.S. Army	
TF 11-2717	Pole Line Construction, Part V, Installation of Anchors
TF 11-2718	Pole Line Construction, Part VI, Installation of Guys
TF 11-2827	Climbing and Working on Poles
TF-5660	Motor Connections in Three Phase and Single Phase Induction Motors
TF-6027	Roughing-in Non-Metallic Sheathed Cable
TF-6037	Conduit Installation
TF-6180	Motor Control System

CNTT—A51

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CURRICULUM OUTLINE
FOR
CONSTRUCTION ELECTRICIAN, CLASS A1

A-721-0018

3-16

Prepared By
U.S. NAVAL CONSTRUCTION TRAINING CENTER
Port Hueneme, CA. 93043

JUNE 1975

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COMCBLANT	1
CNETS (N43 and N331)	1
CO, CBC, PORHUE (CESO-1571)	1
CO, 31st NAVCONSTREG	1
CO, 20th NAVCONSTREG	1
CO, ACB ONE	1
CO, ACB TWO	1
NAVEDTRAPRODEVCEN (ETM-2)	1
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HQ ATC (DCS/TT/TTMS), RANDOLPH AFB, TX	2
CO, USMC ENGR SCOL, CAMP LEJUNE, NC	2
TOTAL	22

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TITLE PAGE

TITLE: Construction Electrician Class "A"

COURSE NO.: A-721-0018

COURSE LENGTH: 241 hours contact time

TAUGHT AT: Naval Construction Training Center, Port Hueneme, Ca. 93043
Naval Construction Training Center, Gulfport, Ms. 39502

CLASS CAPACITY: Normal: 24
Maximum: 24
Minimum: 12

INSTRUCTOR REQUIREMENT PER CLASS: Class: 24/1
Shop: 8/1
Field: 6/1

COURSE CURRICULUM MODEL MANAGER: Naval Construction Training Center,
Port Hueneme, California 93043

CURRICULUM CONTROL: CNTECHTRA

QUOTA MANAGEMENT AUTHORITY: CNTECHTRA

QUALITY CONTROL: BUPERS

APPROVAL/IMPLEMENTATION DATE: CNTECHTRA ltr N335:stb, 1500, Ser 33/504
of 24 June 1975

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INTRODUCTION

1. This curriculum was developed by Naval Construction Training Center, Port Hueneme, California 93043, as Course Model Manager, and is effective upon final approval of the Chief of Naval Technical Training.

2. Commands are invited to submit explicit comments on the content of this curriculum to the Commanding Officer, Naval Construction Training Center, Port Hueneme, California 93043, with copies to the Chief of Naval Technical Training, Naval Air Station Memphis (75), Millington, Tennessee 38054, and the Commanding Officer, Naval Construction Training Center, Gulfport, Mississippi 39502.

3. Training notes

This course has been developed and designed in accordance with the principles of systems engineering. In order to insure that the objectives of each unit are met, it is expected that the instructor will teach the topics as outlined in accordance with the referenced publications. Deviation is allowed only to exceed or supplement the required instruction. Lesson outlines in the instructor guides are to be used as a guide in the presentation of the lesson. While it is compulsory that all objectives of each training period be met, it is recognized that the specified times established for each lesson may vary with the achievement level of each group of students, the number of students per cycle, the instructor-to-student ratio, and the availability of facilities. It is the responsibility of the school to provide for the efficient implementation and administration of this publication and to ensure that each of the learning activities outlined herein is taught in a manner which provides a maximum gain in knowledge and skill for each student.

4. Training Methods

a. The traditional methods of conference, demonstration and practical exercise are used during this course of instruction. In keeping with changes which potentially will benefit the instruction, other methods are also included:

(1) Information presentations: These are designed primarily to make information available in a group setting, have no objectives, and are not instructional. No tests are given on information presentations.

(2) Self-study text materials: These individualized materials do have objectives and are instructional and will be tested at the end of each section of the student workbook.

(3) Group audio-visual presentations: These presentations can be either informational or instructional.

(4) Progress evaluation test: Tests that are inserted at critical points to determine students' capabilities to perform objectives.

(5) Group interactive lecture: Group participates by responding to situations presented verbally by the instructor or in the workbooks provided to the students.

b. Schools will emphasize the importance of performance-orientated trainig wherein learning-by-doing rather than listening and watching is practiced. Time devoted to the traditional methods of instruction will be limited in favor of the methods depend to a great extent on availability of audio-visual aids, there are other alternatives that can be developed at the training center using existing material.

c. The student learns best in a job-relevant environment. Time devoted to lectures, conferences, and demonstrations should be held to the minimum required for explaining the objectives, course organization, safety precautions, and other introductory-type subjects pertinent to the course.

5. Testing Concepts:

Criterion testing (tests designed to measure performance of specific objectives) will be used to measure student performance. Each student will be tested on each learning objective to the level of proficiency stated in the objective. A series of performance tests for each scheduled evaluation is provided at the end of each unit. Each test requirement or problem is closely related to specific training objectives and performance standards. Standards of proficiency are stated explicitly in performance tests. Proficiency testing is conducted using the pass/fail, go/no go technique. Student performance during the formative tests will provide indicators as to need for additional training on an individual or group basis. Performance on the pass/fail tests conducted after each phase of the course provides the basis for determining whether or not a student will be graduated. Unit tests will be used in determining class standing and honor graduates.

6. How to use Instructor Guides

Instructor Guides are provided for each topic and include supporting instructional materials and aids identified by the topic number preceded by a letter code designation. The letter code key is as follows:

AS - Assignment Sheet
JS - Job Sheet
IS - Information Sheet
CN - Class Notes
OS - Operation Sheet
T - Test
FT - Final Test
TR - Transparencies
DS - Diagram Sheet
PS - Problem Sheet
PE - Performance Evaluation
WB - Workbook
G - Definition of item in general

A complete list of all supporting materials and aids is documented with full descriptive titles in ANNEX I thru VII.

The Instructor guides are intended to be used as master lesson plans subject to personalization by the individual instructor. In all cases, it is expected that the instructor will study the references in preparation for annotating the guide. It is also expected that each instructor will develop an appropriate introduction for each topic that will (1) create interest, (2) show the value of the topic to the student, (3) relate the topic to previous and future topics in the course, and (4) communicate the learning objectives to the student. Well prepared introductions will then provide the important motivational conditioning to establish readiness and effect for learning appropriate to each topic.

The first page of each instructor guide contains the following functional information:

1. Topic of Lesson
2. Time in Periods
3. References
4. Instructional Aids
5. Instructional Materials
6. Objectives (Terminal and Enabling)
7. Topic Criterion Test (as applicable)
8. Homework Assignment (when applicable)

The pages following page 1 of each instructor guide provide in a three-column format the teaching/learning procedures for conducting the lesson. The left-hand column includes the outline of instructional content required by the objectives; the center column includes recommended instructor activities or methodology; the right-hand column contains recommended student learning activities.

a. While the methodology and student learning activities documented in each instructor guide have been tested and proven to be effective for the lead school, those schools implementing this curriculum are encouraged to exercise creativity in designing learning exercises and conceiving methods and techniques to meet course objectives.

b. Instructors and supervisors of instruction should constantly evaluate the program and seek new and more effective methods, content and procedures to improve their instruction. When changes in this curriculum become necessary because of new developments or because of needs that become evident through experience gained in using the curriculum, the school command is encouraged to take appropriate action. The types of changes and the conditions under which they will be made are as follows:

(1) Type A changes and those of course length; change in title of the course; or addition, deletion or alteration of blocks of subject matter to such an extent that the objectives of courses are changed, or that logistics, personnel allocations, funds and the like become involved. For Type A changes, the CNTECHTRA (Code 0162A) must participate in the planning, development and execution. Type A changes may not be made effective until approved the Chief of Naval Technical Training.

(2) Type B changes are those within established structure of the course such as changes in instructional emphasis that are brought about by changes in topic content or time re-allocation (other than minor adjustments in time), changes in instructional procedures, and similar actions that will alter the objectives of a topic. For Type B changes, approval of the Chief of Naval Technical Training must be gained prior to implementing the changes.

(3) Type C changes include corrections of clerical errors; insertion of titles and designations of new films; publications, and equipment; minor adjustments in time allocations; additional suggestions to assist the instructor and so forth. For Type C changes, the Chief of Naval Technical Training must be notified in writing of the nature of the changes, with sufficient information on the mechanics of the changes to make possible the maintenance of an up-to-date copy of the curriculum. In order to avoid unnecessary paper work, Type C changes may be accumulated and reported only when the quantity or occasion warrants.

c. Formative Test: During the classroom phase of the instruction at specific checkpoints identified by the instructor, informal written tests will be administered to demonstrate mastery of specific subjects. These tests are designed to reinforce learning. Tests are administered at the end of each unit of instruction. Formal tests may vary from 10 - 25 multiple-choice questions and will have bearing to influence class standing and to determine honor graduates.

7. Peer Instruction

It is envisioned that those students who learn faster or who have previously developed a particular skill can be used (after demonstrating proficiency in the subject) as peer instructors to assist slow learners. This technique enhances motivation and early subject mastery while minimizing requirements. Care should be taken not to pair students with widely disparate learning abilities. i.e., a student who has finished step 10 should not be paired with a student who is finishing step 2. He should help a student who is finishing step 8 or 9 and a student who has finished step 3 or 4 should help the student at step 2. In this way, there is a better chance that there will be no resentment of the peer instructor and he will also receive reinforcement from the instruction, having just completed the task himself.

COURSE DATA PAGE

COURSE MISSION: Upon completion of the training outline in this course, the student will be able to perform apprentice duties pertaining to the installation of overhead distribution systems up to 5,000 volts, operate power plants up to 200 KW singly or in parallel, install and operate a tactical field telephone system, install interior wiring systems with associated electrical devices and equipment, and perform electrical tests and maintenance on 115/230 volt circuits.

PERSONNEL AND RATINGS ELIGIBLE: Selected CR, CA, CN, SN and FN volunteers for Group VIII rating.

OBLICATED SERVICE: See TRANSMAN, NAVPERS 15909 (Series)

NEC GAINED: None

PHYSICAL REQUIREMENTS: Vision correctable to 20/20 with accurate color perception

SECURITY CLEARANCE REQUIRED: None

PREREQUISITE TRAINING AND/OR BASIC BATTERY TEST SCORES REQUIRED: GCT + ARI = 105 and successful completion of Basic Electricity/Electronics Programmed Instruction Course, NAVPERS 94558

GRADING WEIGHT FACTORS: Performance of tasks throughout the course will be graded on a go/no go basis with written tests given at the end of each phase. Final grade to be class ranking specifically designed to enable the Commanding Officer to comply with Bureau of Personnel directives relative to meritorious advancement.

OUTLINE OF INSTRUCTION

TOPIC	Unit 1.1	CLASS	PRACT	TOTAL	PAGE
	Introduction				
1.1.0	NAVCONSTRACEN Indoctrination	4	0	4	4
1.1.1	Registration and Orientation	1	0	1	4
1.1.2	Study Techniques	1	0	1	4
1.1.3	Safety Policies	1	0	1	4
		7	0	7	
	Unit 1.2				
	Pole Climbing Indoctrination				
1.2.1	Pole Climbing Equipment and Techniques	2	9	11	5
1.2.2	Pole Climbing Practice to Qualify	0	12	12	5
		2	21	23	
	Unit 1.3				
	Interior Electrician				
1.3.1	Boxes, Fittings and Electrical Devices	7	0	7	5
1.3.2	Basic Circuits and Blueprints	7	1	8	5
1.3.3	Conductors, Splices and Connectors	1	1	2	5
1.3.4	Code Studies	5	0	5	6
1.3.5	Conduit Installation	2	12	14	6
1.3.6	Non-Metallic Sheathed Cable	2	0	2	6
1.3.7	Service Entrances	2	0	2	6
1.3.8	Light Fixtures	2	0	2	6
1.3.9	Temporary Wiring	1	5	6	6
1.3.10	Hand Tools and Test Equipment	2	3	5	7
1.3.11	Motors, Motor Controllers and Circuits	6	0	6	7
1.3.12	Cubicle Wiring	1	26	27	7
1.3.13	Maintenance and Trouble Shooting	2	7	9	7
	Student Written Evaluation for Class Standing	1	0	1	7
		41	55	96	

TOPIC	Unit 2.1	CLASS	PRACT	TOTAL	PAGE
	Power Generation and Distribution				
2.1.1	Tying Knots	2	4	6	7
2.1.2	Framing Poles	1	5	6	8
2.1.3	Erecting and Setting Poles	2	7	9	8
2.1.4	Mounting Crossarms, Pins and Insulators	2	13	15	8
2.1.5	Guying Poles	2	7	9	8
2.1.6	Stringing Primary Line Conductors	1	10	11	8
2.1.7	Transformers and Protective Equipment	1	5	6	8
2.1.8	Stringing Secondary Mains	1	6	7	8
2.1.9	Transformer Connections	3	4	7	9
2.1.10	Pole Top Rescue	1	6	7	9
2.1.11	Power Plants	2	7	9	9
2.1.12	Systems Testing	1	2	3	9
2.1.13	Disassemble Pole Line	1	10	11	9
	Student Written Evaluation for Class Standing	1	0	1	9
		21	86	107	
	Unit 2.2				
	Field Telephone Communications				
2.2.1	Tactical Field Telephone and Switchboard	2	5	7	10
		2	5	7	
	Graduation	0	1	1	10
		0	1	1	

* Total Periods Classroom: 73
* Total Periods Practical: 168
* Total Periods for Course: 241
** Total Periods GMT: 40
Administrative Time: 07 Periods
Total Weeks for Course: 08

* All periods represent 60 minutes of actual instruction.
** GMT - General Military Training required by OPNAV Instructions 1500.22B, etc.

OUTLINE OF TRAINING OBJECTIVES

Unit 1.1 INDOCTRINATION Contact Hours: 1

Terminal Objective: Upon completion of this unit of instruction the student will have registered for the course, received course text books, answered questions pertaining to key points on the organization, mission and regulations of NAVCONSTRACEN and CBC, reviewed class schedule, been introduced to class counselor, stated the standards of the school, described the benefits that can be derived from good study technique, stated how to report accidents or fire, and listed the safety practices that are enforced in the school.

Topic 1.1.0 NAVCONSTRACEN INDOCTRINATION Contact Hours: 4

Enabling Objectives: Upon completion of this topic the student will have answered questions pertaining to key points on the organization, mission and regulations of CBC and NAVCONSTRACEN. The student will complete the Indoctrination Response Sheet 001/911C with 100% accuracy.

Topic 1.1.1 REGISTRATION AND ORIENTATION Contact Hours: 1

Enabling Objectives: Upon completion of this topic the student will have registered for the course, received text books, met his class counselor, and stated the standards of the school without reference to written material.

Topic 1.1.2 STUDY TECHNIQUES Contact Hours: 1

Enabling Objectives: Upon completion of this topic the student will demonstrate his ability to state orally the benefits of good study techniques. He will do this in answer to key questions based on his information sheet and on the instructor's emphasis during the period.

Topic 1.1.3 SAFETY POLICIES Contact Hours: 1

Enabling Objectives: Upon completion of this topic the student will demonstrate his ability to answer specific oral or written questions regarding key policies governing the safe handling of equipment and materials, consideration for personal safety (including avoiding and eliminating fire hazards); methods of reporting accidents and fires; and, duties and responsibilities of the class safety man.

Unit 1.2 POLE CLIMBING INDOCTRINATION Contact Hours: 23

Terminal Objective: Upon completion of this unit of instruction the student will be able to select, adjust, and use pole climbing equipment to climb a 35 foot pole in accordance with the Programmed Instruction, Series 071/590, "Pole Climbing Techniques".

Topic 1.2.1 POLE CLIMBING EQUIPMENT AND TECHNIQUES Contact Hours: 11

Enabling Objectices: Upon completion of this topic the student will be able to identify, inspect, adjust and perform maintenance on climbing equipment prior to climbing a 20 foot practice pole. Steps of procedure will be performed in accordance with the Programmed Instruction, series 071/590, "Pole Climbing Techniques", without error.

Topic 1.2.2 PRACTICE POLE CLIMBING TO QUALIFY Contact Hours: 12

Enabling Objectives: Upon completion of this topic the student will be able to climb a 35 foot pole to within 2 feet from the top, belt off, circle the pole clockwise and counterclockwise, unbelt and descend to the ground. Pole climbing techniques will be performed in accordance with steps of procedure outlined in the Programmed Instruction, Series 071/590, "Pole Climbing Techniques", without error in order to qualify for "Lineman".

Unit 1.3 INTERIOR ELECTRICIAN Contact Hours: 108

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Topic 1.3.1 BOXES, FITTINGS AND ELECTRICAL DEVICES Contact Hours: 7

Enabling Objectives: Upon completion of this topic the student will be able to install boxes, fittings, and electrical devices within an open framed building. Evaluation of this topic will be conducted during Topic CE "A" IG 1.2.12 and in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Installation of electrical materials will be 100% correct.

Topic 1.3.2 BASIC CIRCUITS AND BLUEPRINTS Contact Hours: 8

Enabling Objectives: Upon completion of this topic the student will be able to draw basic circuits and read blueprints. Completed drawings will contain incandescent and flourescent lighting systems, receptacle circuits and required switches. Drawings will conform to the requirements outlined in the Information Sheet CE "A" IS 1.3.2.1.

Topic 1.3.3 CONDUCTORS, SPLICES AND CONNECTORS Contact Hours: 2

Enabling Objectives: Upon completion of this topic the student will be able to make interior wiring splices and connections using insulated copper conductors, wirenuts, split-bolt connectors and electrical tape. Splices and connections will be made in accordance with the Job Sheet CE "A" JS 1.3.3.1, "Conductors, Splices and Connectors". Practical application will be 100% correct.

Topic 1.3.4 CODE STUDIES Contact Hours: 5

Enabling Objectives: Upon completion of this topic the student will be able to select the correct code ruling that applies to each item of electrical material and equipment to be installed in the open framed building and the reinforced concrete slab area with surrounding concrete unit wall. Selections will be in accordance with the National Electrical Code and the Information Sheet CE "A" IS 1.3.4.1, "Code Studies". Code rulings selections will be 100% correct.

Topic 1.3.5 CONDUIT INSTALLATION Contact Hours: 14

Enabling Objectives: Upon completion of this topic the student will be able to install rigid metal conduit, rigid non-metallic conduit, and electrical metallic tubing. Installation will be performed in a reinforced concrete slab area with surrounding concrete masonry unit wall in accordance with the Job Sheet CE "A" JS 1.3.5.1,"Conduit Installation in Concrete Slab and Concrete Unit Wall". Conduit runs will be installed 100% correct.

Topic 1.3.6 NON-METALLIC SHEATHED CABLE Contact Hours: 2

Enabling Objectives: Upon completion of this topic the student will be able to install non-metallic sheathed cable in the open framed building. Installation of type "NM" cable will be performed during Topic CE "A" IG 1.3.12 and in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring" Cable runs will be installed 100% correct.

Topic 1.3.7 SERVICE ENTRANCES Contact Hours: 2

Enabling Objectives: Upon completion of this topic the student will be able to install a single-phase, three-wire, 120/208 volt service for the interior wiring system in the open framed building. Installation of the service will be done during Topic 1.3.12, and in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Service entrance installation will be 100% correct.

Topic 1.3.8 LIGHT FIXTURES Contact Hours: 2

Enabling Objectives: Upon completion of this topic the student will be able to install flourescent and incandescent lighting fixtures in the open framed building. Installation of fixtures will be done during Topic 1.3.12, and in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Fixtures will be installed 100% correct.

Topic 1.3.9 TEMPORARY WIRING Contact Hours: 6

Enabling Objectives: Upon completion of this topic the student will be able to install a pole mounted temporary wiring system required for new construction. Installation will conform to the drawings and procedures outlined in the Job Sheet CE "A" JS 1.3.9.1, "Temporary Wiring". Installation will be 100% correct.

Topic 1.3.10 HAND TOOLS AND TEST EQUIPMENT Contact Hours: 5

Enabling Objective: Upon completion of this topic the student will be able to use handtools and test equipment required to install and test electrical material and equipment. Steps of procedure will be conducted at an assigned test bench in accordance with the Job Sheet CE "A" JS 1.3.10.1, "Handtools and Test Equipment". Use of handtools and testing will be executed 100% correct.

Topic 1.3.11 MOTORS, MOTOR CONTROLLERS AND CIRCUITS Contact Hours: 6

Enabling Objectives: Upon completion of this topic the student will be able to install a motor, motor controller, and associated circuits within the open framed building. Installation will take place during Topic 1.3.12, and in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Equipment will be installed 100% correct.

Topic 1.3.12 CUBICLE WIRING Contact Hours: 27

Enabling Objectives: Upon completion of this topic the student will be able to use electrician's tools and install boxes, fittings, motor, motor controller, push button station, circuit breaker panel, rigid steel conduit, insulated conductors, non-metallic sheathed cable, electrical devices and fixtures. Installation will be within the open framed building in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring", and will be 100% correct.

Topic 1.3.13 MAINTENANCE AND TROUBLESHOOTING Contact Hours: 9

Enabling Objectives: Upon completion of this topic the student will be able to perform maintenance and troubleshooting procedures on interior wiring circuits, motor controllers, motors and associated equipment. Steps of procedure will be in accordance with the Job Sheet CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting" and will be 100% correct.

STUDENT WRITTEN EVALUATION FOR CLASS STANDING Contact Hours: 1

Unit 2.1 POWER GENERATION AND DISTRUBUTION Contact Hours: 107

Terminal Objective: Upon completion of this unit of instruction the student will be able to install an overhead distribution system up to 5,000 volts, and operate alternating current generators up to 200 kw, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Topic 2.1.1 TYING KNOTS Contact Hours: 6

Enabling Objectives: Upon completion of this topic the student will be able to tie a timber-hitch, half-hitch, clove-hitch, bowline, grunt's knot and properly make up a handline for stowage. Knots will be tied in a 6 foot length of 1/2 inch line in accordance with procedures outlined in Job Sheet CE "A" JS 2.1.1.1, "Tying Knots". Knot tying procedures will be executed without error.

Topic 2.1.2 FRAMING POLES Contact Hours: 6

Enabling Objectives: Upon completion of this topic the student will be able to frame a power pole in accordance with Job Sheet CE "A" JS 2.1.2.1, "Framing Poles". Framing will be 100% correct.

Topic 2. 1. 3 ERECTING AND SETTING POLES Contact Hours: 9

Enabling Objectives: Upon completion of this topic the student will be able to perform as a crew member, the piking method of raising and setting a 35 foot power pole in accordance with the steps of procedure outlined in the Job Sheet CE "A" JS 2.1.3.1, "Erecting and Setting Poles". Practical performance will be without error.

Topic 2.1.4 MOUNTING CROSSARMS, PINS, AND INSULATORS Contact Hours: 15

Enabling Objectives: Upon completion of this topic the student will be able to mount single and double crossarms and install pins and insulators on the 35 foot poles in accordance with Job Sheet CE "A" JS 2.1.4.1, "Mounting Crossarms, Pins, and Insulators". Steps of procedure will be performed 100% correct.

Topic 2.1.5 GUYING POLES Contact Hours: 9

Enabling Objectives: Upon completion of this topic the student will be able to construct and install guy assemblies using the necessary tools and equipment. Installation will be 100% correct in accordance with Job Sheet CE "A" JS 2.1.5.1, "Guying Poles".

Topic 2.1.6 STRINGING PRIMARY LINE CONDUCTORS Contact Hours: 11

Enabling Objectives: Upon completion of this topic the student will be able to install primary line conductors in accordance with procedures and safety precautions outlined in the Job Sheet CE "A" JS 2.1.6.1, Stringing Primary Line Conductors". Installation will be done without error.

Topic 2.1.7 TRANSFORMERS AND PROTECTIVE EQUIPMENT Contact Hours: 6

Enabling Objectives: Upon completion of this topic the student will be able to install a three phase transformer bank with associated protective equipment. Installation will be 100% correct in accordance with Job Sheet CE "A" JS 2.1.7.1, "Transformers and Protective Equipment".

Topic 2.1.8 STRINGING SECONDARY MAINS Contact Hours: 7

Enabling Objectives: Upon completion of this topic the student will be able to install the secondary mains required for the secondary distribution of power at 120/208 volts. Installation will conform to the Job Sheet CE "A" JS 2.1.8.1, "Stringing Secondary Mains". Steps of procedure will be performed 100% correct.

Topic 2.1.9 TRANSFORMER CONNECTIONS Contact Hours: 7

Enabling Objectives: Upon completion of this topic the student will be able to connect the three phase transformer bank to the primary and secondary distribution systems. Connections will be made without error and in accordance with the Job Sheet CE "A" JS 2.1.9.1, Transformer Connections".

Topic 2.1.10 POLE TOP RESCUE Contact Hours: 7

Enabling Objectives: Upon completion of this topic the student will be able to perform pole top rescue procedures while adhering to required safety precautions. Rescue performance will be in accordance with Job Sheet CE "A" JS 2.1.10.1, "Pole Top Rescue". Steps of procedure will be executed 100% correct.

Topic 2.1.11 POWER PLANTS Contact Hours: 9

Enabling Objectives: Upon completion of this topic the student will be able to operate a power plant housing generators with varying capacities up to 200 kw. Generators will be operated singly or in parallel in accordance with procedures outlined in the Job Sheet CE "A" JS 2.1.11.1, "Power Plants". Operating procedures will be performed without error.

Topic 2.1.12 SYSTEMS TESTING Contact Hours: 3

Enabling Objectives: Upon completion of this topic the student will be able to conduct various tests on transformer secondaries and check system's grounds. Ground checks will be performed while the system is de-energized, and the secondary system's testing will be conducted while systems are energized by the power plant. Testing and ground check procedures as outlined in Job Sheet CE "A" JS 2.1.12.1, "Systems Testing" will be executed 100% correct.

Topic 2.1.13 DISASSEMBLE POLE LINE Contact Hours: 11

Enabling Objectives: Upon completion of this topic the student will be able to disassemble the primary and secondary distribution systems and associated materials and equipment. Disassembly and storage of materials will be done in accordance with the Job Sheet CE "A" JS 2.1.13.1, "Disassemble Pole Line". Steps of procedure will be done without error.

STUDENT WRITTEN EVALUATION FOR CLASS STANDING Contact Hours: 1

Unit 2.2 Contact Hours: 7

Terminal Objective: Upon completion of this unit of instruction the student will be able to install and operate tactical field phones and switchboards under simulated field conditions in accordance with the Job Sheet CE "A" JS 2.2.1.1, "Installation and Operation of Tactical Field Phones and Switchboards".

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Topic 2.2.1 TACTICAL FIELD TELEPHONES AND SWITCHBOARDS Contact Hours: 7

Enabling Objectives: Upon completion of this topic the student will be able to install and operate tactical field telephones and switchboards using field wire, type TA-312/PT field telephone sets and type SB-22A/PT switchboard. Installation and operation procedures will be 100% correct in accordance with the Job Sheet CE "A" JS 2 2.1.1, "Tactical Field Telephones and Switchboard".

GRADUATION Contact Hours: 1

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ANNEX I

TEXTS

1. Tools and Their Uses, NAVPERS 10085-B.
2. Construction Electrician 3 & 2, NAVPERS 10636-G.
3. NAVFAC MO-116, "Facilities Engineering Electrical Interior Facilities", March 1972.
4. TM5-704, "Construction Print Reading in the Field", August 1952.
5. TM11-5805-262-12, "Switchboards, Telephone, Manual, SB-22/PT and SB-22A/PT".
6. Allen-Bradley Manual, "Wiring Diagrams for Full Voltage Starting Switches".
7. Lineman's and Cablemen's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, New York.
8. National Electrical Code (latest edition), National Fire Protection Association, No. 70, 470 Atlantic Avenue, Boston Massachusetts 02210.
9. Programmed Instruction, Series 058/551A, "Electrical Symbols".
10. Programmed Instruction, Series 071/590, "Pole Climbing Techniques".

ANNEX II

REFERENCES

1. TM5-725, "Rigging".

2. American Electrician's Handbook, 9th edition, Croft, Carr and Watt; McGraw-Hill Book Co., New York, New York.

3. National Electrical Safety Code, 1973 edition, ANS1-C2; Institute of Electrical and Electronics Engineers Inc., 345 East 47th Street, New York, New York 10017.

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ANNEX III

TOOLS, EQUIPMENT AND MATERIALS

TOOLS

FSN/MFG. NO.	ITEM	QTY	UNIT COST
5110-00-340-3276	Buck-saw	2 ea.	2.25
5120-00-267-7023	Cable Grip	8 ea.	6.00
5120-00-251-7574	Cant Hooks	6 ea.	5.60
5120-00-223-8419	Carrying Hooks	8 ea.	5.60
5120-00-516-3802	Digging Bar	2 ea.	8.80
MFG 82063 MPN 6025	File Gauge	24 ea.	10.00
5120-00-221-2050	Framing Square	4 ea.	4.40
5120-00-618-6898	Hand Bender, E.M.T., 1/2"	12 ea.	2.63
5120-00-618-6899	Hand Bender, E.M.T., 3/4"	12 ea.	4.12
MFG 04065 MPN 843	Jenny (mule), Pole	1 ea.	33.44
MFG 82063 MPN 1306	Pole Top Rescue Harness	1 ea.	40.00
MFG 73569 MPN C400-0648	Pole Top Gin with block and tackle	1 ea.	342.70
5120-00-223-8852	Pike Poles	8 ea.	10.92
MFG 04065 MPN 1800	Ratchet Bender	1 ea.	310.00
5120-00-293-3336	Shovel, Short, "D" Handle	4 ea.	2.83
5120-00-188-8450	Shovel, Straight	2 ea.	1.90
5120-00-188-8444	Shovel, Spoon	4 ea.	8.90
4020-00-968-1352	Tag Line	1 rl.	25.00
5120-00-596-8520	Tamping Bar	4 ea.	9.00
5440-00-061-8900	6 foot Step Ladder	12 ea.	53.00
5440-00-223-6026	20 foot Extension Ladder	1 ea.	43.26

TOOLS, (Cont'd)

KITS

FSN/MFG NO.	ITEM	QTY	UNIT COST
Facility 01102A Assembly 80006	Kit, Electricians, Tools	6 ea.	355.25
Facility 01102A Assembly 80007	Kit, Lineman's Tools	6 ea.	709.09
Facility 01102A Assembly 80008	Kit, Electronics Maintenance Tools	6 ea.	245.93

EQUIPMENT

MAJOR

6258-307-7688	Air Circuit Breaker, Model K600 Type K60, Generator Switchgear	1 ea.	1,021.00
6258-307-7689	Air Circuit Breaker, Model K600 Type K60, Generator Switchgear	1 ea.	1,021.00
6258-307-7753	Air Circuit Breaker, Model AK-2-25, Generator Switchgear	1 ea.	694.00
6258-307-7755	Air Circuit Breaker, Model AK-2-25, Generator Switchgear	1 ea.	694.00
NAVFAC CODE 512111 NSN 6115-00-118-1241	Generator, Diesel Driven, Portable Skid-mounted, Liquid Cooled, AC, 15kw, 0.8 P.F., 50/60 Cycle, 3 Phase, 1500/1800 RPM, Engine Serial #3207415	1 ea.	6,520.00
NAVFAC CODE 512111 NSN 6115-00-118-1241	Generator, Diesel Driven, Portable Skid-Mounted, Liquid Cooled, AC, 15kw, 0.8 P.F., 50/60 Cycle, 3 Phase, 1500/1800 RPM, Engine Serial #3207441	1 ea.	6,520.00
6258-00-307-9233	Load Bank, Generator, Portable, Reconnectable, 208/240/416-480 Volts, Single Phase and 3 Phase, 5 kw to 250 kw Capacity	1 ea.	4,434.00

MAJOR EQUIPMENT (Cont'd)

FSN/MFG NO.	ITEM	QTY	UNIT COST
NAVFAC CODE 371001 NSN 2CD 3830-0108142	Earth Auger, Skid mtd Turntable for 2 1/2 ton Military Truck	1 ea.	21,250.00
NAVFAC CODE 072300 NSN 2320-00-805-3540	Truck, Telephone and Pole Line Construction, 2 1/2 ton 4 x 6 CED w/winch, A frame	1 ea.	18,000.00
1HC5805-715-6171 6258-307-6528	Switchboard, Telephone, Manual, Field Type, for interconnecting 12 circuits, powered by two 1.5 volt dry cell batteries, Model SB-22A/PT	1 ea.	419.00
TEST EQUIPMENT			
70Z 6625-00-SPH-0044	AC Power Circuit Analyzer	2 ea.	150.00
	Ammeter		
9ND 6625-00-816-5519	Clamp-on Ammeter	6 ea.	77.00
INM 6625-00-243-3132	Phase Sequence Meter	6 ea.	45.50
9NJ 6625-00-004-9536	Simpson 260 Multimeter	24 ea.	80.00
9ND 6625-00-224-6135	Vibroground (Groundmeter)	6 ea.	168.00
MISCELLANEOUS EQUIPMENT			
MFG 04065 MPN 5XBH02A	Motors, Split Phase, 1/3 H.P.		33.00
MFG 04065 MPN SBG-1	Motor Controllers		65.00
	Practice Poles, 20 foot.		
5510-00-268-3132	Practice Poles, 35 foot.		130.00
MFG 04065 MPN B-30	Push-button Stations, Stop-Start		12.00
70L 5925-LL-CCO-4722	Temporary Power Panel, 50 Amp	1 ea.	193.69
70L 5935-LL-CCO-4724	Connector Body, Armored w/boot	1 ea.	23.00
9ZD 6145-00-617-1374	Wire, Electric, 4 Conductor, #6 GAWG, per ft.		
	Temporary Power Pole & Panel Assembly, 50 Amp.		
5805-00-543-0012	Telephone, Tactical Field, Type TA-312/PT	1 ea.	120.00

MATERIALS

1. Anchor rods and expanding type anchors.
2. Batteries, BA-20 .
3. Boxes, non-metallic.
4. Boxes, steel.
5. Braces, (Flat).
6. Cable, non-metallic-sheathed.
7. Circuit breakers.
8. Circuit breaker panels.
9. Crossarms and mounting hardware.
10. Electrical devices and fittings.
11. Electrical tape.
12. Electrical metallic tubing.
13. Field telephone wire, WD-2/TT.
14. Fuse cutouts.
15. Ground rod, copperweld, 8 foot x 5/8" diameter
16. Ground wire, #8 AWG, bare, solid, copper.
17. Guy wire.
18. Guy grips, preformed.
19. Guy attachments.
20. Lightning arresters.
21. Lighting fixtures, incandescent and flourescent.
22. Line, 6 foot lengths of 1/2"
23. Motors.
24. Motor controllers.

MATERIALS (Cont'd)

25. Pin insulators.

26. Primary conductors, #6 AWG, M.H.D.

27. Rigid non-metallic conduit.

28. Rigid steel conduit.

29. Secondary conductors, #2 AWG, stranded, insulated, copper.

30. Secondary racks.

31. Single conductor, #12 AWG, solid, copper.

32. Split-bolt connectors.

33. Strand vise with strand vise hook.

34. Strain insulators.

ANNEX IV

TRAINING AIDS AND DEVICES

FILMS (Commercial)

1. CLI-001, "Climbing with Confidence" (28 min.).
2. HOW-001, "How Distribution Transformers are Made" (20 min.).
3. ITS-001, "It's CSP for Me" (10 min.).
4. POL-001, "Pole Top Rescue and Closed Heart Massage" (28 min.).

FILMS (U.S. Navy)

1. MA-5741-A2, "Erecting Large Poles" (21 min.).
2. MA-2564, "Installation of Crossarms" (18 min.) (Obsolete).
3. MA-9559, "First Aid, Part IV, Resuscitation, Mouth-to-Mouth, Mouth-to-Nose" (23 min.).
4. MC-8317. "Lifeline of the Lineman" (15 min.) (Obsolete).
5. MN-10386A, "Sailors in Green" (28 min.).
6. MN-6990, "Discipline Pays Off" (11 min.).

FILMS (U.S. Army)

1. TF 11-2717, "Pole Line Construction, Part V, Installation of Anchors" (12 min.).
2. TF 11-2718, "Pole Line Construction, Part VI, Installation of Guys" (20 min.).
3. → TF 11-2827, "Climbing and Working on Poles" (25 min.). - B+W - 1960
4. TF 11-3619, "SB-22/PT, Part I, Characteristics and Installation" (20 min.).
5. TF 11-3620, "SB-22/PT, Part II, Operation and Preventive Maintenance" (16 min.).
6. TF-5660, "Motor Connections in Three Phase & Single Phase Induction Motors" (20 min.) (Air Force).
7. TF-6027, "Roughing-in non-metallic sheathed cable" (15 min.) (Air Force).

FILMS (U.S. Army) (Cont'd)

8. TF-6037, "Conduit Installation" (17 min.) (Air Force).

9. TF-6180, "Motor Control Systems" (16 min.) (Air Force).

10. TF 11-3600, "Tactical Cable Construction" (23 min.).

FILMS (Obsolete)

1. OE-377, "Cable Surface Wiring" (15 min.).

2. OE-382, "Power Conduit Bending" (17 min.).

3. OE-386, "Split-Phase Motor Principles" (20 min.).

DISPLAY BOARDS

1. Crossarm Construction, Primary Line.

2. Conduit.

3. Electrical Material Display board.

4. Flourescent and Incandescent Lighting.

5. Ground Fault Protection.

6. Kit, 80006, Electrician's Tools.

7. Kit, 80007, Lineman's Tools.

8. Kit, 80008, Electronics Maintenance Tools.

9. Motor Controller.

10. Non-metallic sheathed Cable Circuits

11. Pole Line Erection Tools.

12. Pole Line Hardware, Insulators and Protective Devices.

13. Pole Guying Hardware.

14. Primary and Secondary Ties with Deadend and Protective Devices.

15. Single Phase AC Motor, Cutaway.

16. Splices and Connections.

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DISPLAY BOARDS (Cont'd)

17. Three Phase Motor, Disassembled.

18. Transformer Connections.

19. Transformer Connections Diagrams.

LOCALLY PREPARED MATERIALS

1. Job Sheets.

   a. CE "A" JS 1.3.3.1, "Conductors, Splices and Connectors".

   b. CE "A" JS 1.3.5.1, "Conduit Installation in Concrete Slab and Cinder Block Wall".

   c. CE "A" JS 1.3.9.1, "Temporary Wiring".

   d. CE "A" JS 1.3.10.1, "Hand Tools and Test Equipment".

   e. CE "A" JS 1.3.12.1, "Cubicle Wiring".

   f. CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting".

   g. CE "A" JS 2.1.1.1, "Tying Knots".

   h. CE "A" JS 2.1.2.1, "Framing Poles".

   i. CE "A" JS 2.1.3.1, "Erecting and Setting Poles".

   j. CE "A" JS 2.1.4.1, "Mounting Crossarms, Pins and Insulators".

   k. CE "A" JS 2.1.5.1, "Guying Poles".

   l. CE "A" JS 2.1.6.1, "Stringing Primary Line Conductors".

   m. CE "A" JS 2.1.7.1, "Transformers and Protective Equipment".

   n. CE "A" JS 2.1.8.1, "Stringing Secondary Mains".

   o. CE "A" JS 2.1.9.1, "Transformer Connections".

   p. CE "A" JS 2.1.10.1, "Pole Top Rescue".

   q. CE "A" JS 2.1.11.1, "Power Plants".

   r. CE "A" JS 2.1.12.1, "Systems Testing".

JOB SHEETS (Cont'd)

s. CE "A" JS 2.1.13.1, "Disassemble Pole Line".

t. CE "A" JS 2.2.1.1, "Tactical Field Telephones and Switchboard".

2. Information Sheets.

a. CE "A" IS 1.3.1.1, "Boxes, Fittings and Electrical Devices".

b. CE "A" IS 1.3.2.1, "Basic Circuits and Calculations".

c. CE "A" IS 1.3.4.1, "Code Studies".

d. CE "A" IS 1.3.5.1, "Under Slab Conduit Installation".

e. CE "A" IS 1.3.8.1, "Light Fixtures".

f. CE "A" IS 1.3.11.1, "Single Phase Motors".

g. CE "A" IS 1.3.11.2, "Three Phase Motors".

h. CE "A" IS 1.3.11.3, "Motor Control".

3. Drawings.

a. CE "A" DWG 1.3.13.1, "Cubicle Wiring, Room Series # 1 thru 6".

b. CE "A" DWG 2.1.9.1, "Primary and Secondary Distribution Jumper Connections".

c. NAVFAC DWG #1109381, "Advanced Base Standard Pole Line".

ANNEX V

TRAINING AIDS EQUIPMENT

1. 16mm movie projector.

2. Opaque projector.

ANNEX VI

FORMS

1. None.

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ANNEX VII

MASTER SCHEDULE

FIRST WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
1.0.0	C	1	Command/Base Indoctrination	24/1
		2		
1.0.1	C	3	Chaplain's Lecture	24/1
1.0.2	C	4	Military Courtesies and Uniform Grooming Standards	24/1
1.1.1	C	5	Registration and Orientation	24/1
1.1.2	C	6	Study Techniques	24/1
1.1.3	C	7	Safety Policies	24/1
SECOND DAY				
1.2.1	C	8	Pole Climbing Equipment and Techniques	24/1
	P	9		6/1
	C	10		24/1
	P	11		6/1
		12		
		13		
		14		
1.0.3	C	14.5	Aerobics Lecture	24/1
THIRD DAY				
1.2.1	P	15	Pole Climbing Equipment and Techniques	6/1
		16		
		17		
1.0.3	F	17.5	Aerobics	24/1
1.2.1	P	18	Pole Climbing Equipment and Techniques	6/1
		19		
1.3.1	C	20	Boxes, Fittings and Electrical Devices	24/1
		21		
FOURTH DAY				
1.2.2	P	22	Pole Climbing Practice to Qualify	6/1
1.3.1	C	23	Boxes, Fittings and Electrical Devices	24/1
		24		
		25		
		26		
		27		
1.3.2	C	28	Basic Circuits and Blueprints	24/1

FIRST WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIFTH DAY				
1.3.2	C	29	Basic Circuits and Blueprints	24/1
		30		
		31		
1.0.4	C	32	Military Behavior and Conduct Ashore	24/1
		33		
		34		
1.0.17	F	35	Close Order Drill	24/1
1.0.3	F	35.5	Aerobics	8/1
SECOND WEEK				
FIRST DAY				
1.2.2	P	1	Pole Climbing Practice to Qualify	6/1
1.3.2	C	2	Basic Circuits and Blueprints	24/1
		3		
		4		
	P	5		24/1
1.3.3	C	6	Conductors, Splices and Connectors	24/1
	P	7		24/1
SECOND DAY				
1.2.2	P	8	Pole Climbing Practice to Qualify	6/1
1.3.3	P	9	Conductors, Splices and Connectors	24/1
1.3.4	C	9.5	Code Studies	24/1
		10		
		11		
		12		
		13		
		14		
1.3.5	C	14.5	Conduit Installation (in slab)	24/1
THIRD DAY				
1.2.2	P	15	Pole Climbing Practice to Qualify	6/1
1.3.5	C	16	Conduit Installation (in slab)	24/1
		17		
	P	17.5		12/1
		18		
		19		
		20		
		21		
1.0.3	F	21.5	Aerobics	8/1

SECOND WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FOURTH DAY				
1.2.2	P	22	Pole Climbing Practice to Qualify	6/1
1.3.5	P	23	Conduit Installation (in slab)	12/1
		24		
		25		
		26		
		27		
		28		
FIFTH DAY				
1.3.5	P	29	Conduit Installation (in slab)	12/1
		30		
1.3.6	C	31	Non-metallic-sheathed Cable	24/1
1.0.16	C	32	Navy Traditions and Customs	24/1
1.0.8	C	33	Drug and Alcohol Abuse	24/1
		34		
		35		
1.0.3	F	35.5	Aerobics	8/1
THIRD WEEK				
FIRST DAY				
1.2.2	P	1	Pole Climbing Practice to Qualify	6/1
1.3.6	C	2	Non-metallic-sheathed Cable	24/1
1.3.7	C	3	Service Entrances	24/1
		4		
1.3.8	C	5	Light Fixtures	24/1
		6		
1.3.9	C	7	Temporary Wiring	24/1
1.0.3	F	7.5	Aerobics	8/1
SECOND DAY				
1.2.2	P	8	Pole Climbing Practice to Qualify	6/1
1.3.9	C	9	Temporary Wiring	24/1
	P	10		12/1
		11		
		12		
		13		
		14		
1.3.10	C	14.5	Handtools and Test Equipment	24/1

THIRD WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
THIRD DAY				
1.2.2	P	15	Pole Climbing Practice to Qualify	6/1
1.3.10	C	16	Hand Tools and Test Equipment	24/1
		17		
	P	17.5		12/1
		18		
		19		
		20		
1.3.11	C	20.5	Motors, Motor Controllers and Circuits	24/1
		21		
1.0.3	F	21.5	Aerobics	8/1
FOURTH DAY				
1.2.2	P	22	Pole Climbing Practice to Qualify	6/1
1.3.11	C	23	Motors, Motor Controllers and Circuits	24/1
		24		
		25		
		26		
		27		
1.3.12	C	28	Cubicle Wiring	24/1
FIFTH DAY				
1.3.12	P	29	Cubicle Wiring	12/1
		30		
		31		
1.0.6	C	32	Pay and Allowances	24/1
1.0.7	C	33	Financial Responsibility	24/1
		34		
1.0.3	F	35	Aerobics	8/1
FOURTH WEEK				
FIRST DAY				
1.2.2	P	1	Pole Climbing Practice to Qualify	6/1
1.3.12	P	2	Cubicle Wiring	12/1
		3		
		4		
		5		
		6		
		7		
1.0.3	F	7.5	Aerobics	8/1

FOURTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
SECOND DAY				
1.2.2	P	8	Pole Climbing Practice to Qualify	6/1
1.3.12	P	9	Cubicle Wiring	12/1
		10		
		11		
		12		
		13		
		14		
THIRD DAY				
1.2.2	P	15	Pole Climbing Practice to Qualify	6/1
1.3.12	P	16	Cubicle Wiring	12/1
		17		
		18		
		19		
		20		
		21		
1.0.3	F	21.5	Aerobics	8/1
FOURTH DAY				
1.3.12	P	22	Cubicle Wiring	12/1
		23		
		24		
		25		
		26		
		27		
1.3.13	C	28	Maintenance and Troubleshooting	24/1
FIFTH DAY				
1.3.13	C	29	Maintenance and Troubleshooting	24/1
	P	30		8/1
		31		
1.0.9	C	32	Career Opportunities and Special Programs	24/1
		33		
1.0.10	C	34	Basic Principles of Leadership	24/1
1.0.3	F	35	Aerobics	8/1

FIFTH WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
1.3.13	P	1	Maintenance and Troubleshooting	8/1
		2		
		3		
		4		
		5		
	C	6	Student Written Evaluation for Class Standing	24/1
2.2.1	C	7	Tactical Field Telephone and Switchboards	24/1
1.0.3	F	7.5	Aerobics	8/1
SECOND DAY				
2.2.1	C	8	Tactical Field Telephones and Switchboards	24/1
		9		
	P	10		8/1
		11		
		12		
		13		
		14		
2.1.1	C	14.5	Tying Knots	24/1
THIRD DAY				
2.1.1	C	15	Tying Knots	24/1
		16		
	P	16.5		8/1
		17		
		18		
		19		
		20		
2.1.2	C	20.5	Framing Poles	24/1
		21		
1.0.3	F	21.5	Aerobics	8/1

FIFTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FOURTH DAY				
2.1.2	P	22	Framing Poles	8/1
		23		
		24		
		25		
		26		
2.1.3	C	27	Erecting and Setting Poles	24/1
		28		
FIFTH DAY				
2.1.3	P	29	Erecting and Setting Poles	8/1
		30		
		31		
1.0.11	C	32	Navy Human Goals Objectices	24/1
1.0.12	C	33	Sea Power (Seabee History)	24/1
		34		
1.0.13	C	34.5	Safe Driving	24/1
		35		
1.0.3	F	35.5	Aerobics	8/1
SIXTH WEEK				
FIRST DAY				
2.1.3	P	1	Erecting and Setting Poles	6/1
		2		
		3		
		4		
2.1.4	C	5	Mounting Crossarms, Pins and Insulators	24/1
		6		
	P	7		6/1
1.0.3	F	7.5	Aerobics	8/1
SECOND DAY				
2.1.4	P	8	Mounting Crossarms, Pins and Insulators	6/1
		9		
		10		
		11		
		12		
		13		
		14		

SIXTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
THIRD DAY				
2.1.4	P	15 16 17 18 19 20	Mounting Crossarms, Pins and Insulators	6/1
2.1.5	C	20.5 21	Guying Poles	24/1
1.0.3	F	21.5	Aerobics	8/1
FOURTH DAY				
2.1.5	C	22	Guying Poles	24/1
	P	23 24 25 26 27 28		6/1
FIFTH DAY				
2.1.5	P	29	Guying Poles	6/1
2.1.6	C	30	Stringing Primary Line Conductors	24/1
	P	31		6/1
1.0.4	C	32 33	UCMJ	24/1
1.0.19	C	34	Enlisted Performance Evaluations	24/1
1.0.3	F	35	Aerobics	8/1
SEVENTH WEEK				
FIRST DAY				
2.1.6	P	1 2 3 4 5 6 7	Stringing Primary Line Conductors	6/1
1.0.3	P	7.5	Aerobics	8/1

SEVENTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
SECOND DAY				
2.1.6	P	8	Stringing Primary Line Conductors	6/1
		9		
		10		
2.1.7	C	10.5	Transformers and Protective Equipment	24/1
		11		
	P	11.5		6/1
		12		
		13		
		14		
THIRD DAY				
2.1.7	P	15	Transformers and Protective Equipment	6/1
		16		
2.1.8	C	16.5	Stringing Secondary Mains	24/1
		17		
	P	17.5		6/1
		18		
		19		
		20		
		21		
1.0.3	F	21.5	Aerobics	8/1
FOURTH DAY				
2.1.8	P	22	Stringing Secondary Mains	6/1
		23		
2.1.9	C	24	Transformer Connections	24/1
		25		
		26		
	P	27		6/1
		28		
FIFTH DAY				
2.1.9	P	29	Transformer Connections	6/1
		30		
2.1.10	C	31	Pole Top Rescue	24/1
1.0.20	C	32	Educational Opportunities	24/1
1.0.21	C	33	Code of Conduct, Part 1	24/1
1.0.22	C	34	Code of Conduct, Article I	24/1
1.0.3	F	35	Aerobics	8/1

EIGHTH WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
2.1.10	P	1	Pole Top Rescue	6/1
		2		
		3		
		4		
		5		
		6		
2.1.11	C	7	Power Plants	24/1
1.0.3	F	7.5	Aerobics	8/1
SECOND DAY				
2.1.11	C	8	Power Plants	24/1
		9		
	P	9.5		12/1
		10		
		11		
		12		
		13		
		14		
THIRD DAY				
2.1.11	P	15	Power Plants	12/1
		16		
2.1.12	C	16.5	Systems Testing	24/1
		17		
	P	17.5		8/1
		18		
		19		
2.1.13	C	19.5	Disassemble Pole Line	24/1
		20		
	P	20.5		6/1
		21		
1.0.3	F	21.5	Aerobics	8/1

EIGHTH WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FOURTH DAY				
2.1.13	P	22 23 24 25 26 27 28	Disassemble Pole Line	6/1
FIFTH DAY				
2.1.13	P	29 30	Disassemble Pole Line	6/1
	C	31	Student Written Evaluation for Class Standing	24/1
1.0.23	C	32	Code of Conduct, Article II	24/1
1.0.24	C	33	Code of Conduct, Article III	24/1
1.0.25	C	34	Code of Conduct, Article IV	24/1
1.0.3	F	35	Aerobics	8/1

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CONSTRUCTION ELECTRICIAN SCHOOL

CLASS "A"

INSTRUCTOR GUIDES

PHASE 1

3-16

Interior Electrician

MODIFICATIONS

Instructor Guide 1.1.1 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Study Techniques

Average Time: 1 Period (Class)

Instructional Materials:

A. Texts:

  1. How to Study, 5th Edition, Thomas F. Staton, P.O. Box 6133, Montgomery, Alabama 36106.

B. References: None.

C. Tools, Equipment and Materials: None.

D. Training Aids and Devices: None.

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit of instruction the student will have registered for the course, received course textbooks, answered questions pertaining to key points on the organization, mission and regulations of NAVCONSTRACEN and CBC, reviewed class schedule, been introduced to class counselor, stated the benefits that can be derived from good study technique, stated how to report accidents or fire, and listed the safety practices that are enforced in the school.

Enabling Objectives: Upon completion of this topic the student will demonstrate his ability to state orally the benefits of good study techniques. He will do this in answer to key questions based on his information sheet and on the instructor's emphasis during the period. He must be basically correct in this as well as in answer to key questions pertaining to perparation for tests and examinations.

Criterion Test: The student will demonstrate his ability to describe the key points listed in "How To Study", and will exercise good study techniques throughout his assignment to CE School.

Homework: None.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Study Techniques.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Benefits of good study techniques.	1. State information and materials necessary to guide student.	
2. Factors contributing to good study techniques.		
3. Improve reading habits.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

II. Presentation.

- A. Steps of procedure.
  - 1. Benefits of good study techniques.
    - a. Economy of time and effort.
    - b. Study technique.
      - (1) Attitude.
      - (2) Study environment.
      - (3) Time budgeting.
      - (4) Concentration habits.
      - (5) Reading habits.
      - (6) Note taking.
  - 2. Factors contributing to good study techniques.
    - a. Favorable environment.
      - (1) Free from distraction.
      - (2) Proper lighting.
      - (3) Proper temperature.
      - (4) Comfortable furniture.
      - (5) Necessary materials on hand.

b. Study time budget.

(1) Definite study time.

(2) Daily load of study hours.

(3) Avoid interruptions.

3. Improve reading ability.

a. Develop reading habits.

b. Develop better vocabulary.

(1) Use dictionary for definitions.

III. Application.

A. Clear up any area of doubt in regard to study technique.

IV. Summary.

A. Benefits of good study techniques.

B. Factors contributing to good study techniques.

C. Reading ability.

D. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Safety Policies

Average Time: 1 Period (Class)

Instructional Materials:

A. Texts: None.

B. References:

1. NAVSO P-2455, Department of the Navy, Precautions for Shore Activities.

C. Tools, Equipment and Materials: None.

D. Training Aids and Devices: None.

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit of instruction the student will have registered for the course, received course textbooks, answered questions pertaining to key points on the organization, mission and regulations of NAVCONSTRACEN and CBC, reviewed class schedule, been introduced to class counselor, stated the standards of the school, described the benefits that can be derived from good study techniques, stated how to report accidents or fire, and listed the safety practices that are enforced in the school.

Enabling Objectives: Upon completion of this topic the student will demonstrate his/her ability to answer specific oral or written questions regarding key policies governing the safe handling of equipment and materials; consideration for personal safety (including avoiding and eliminating fire hazards); methods of reporting accidents and fires; and, duties and responsibilities of the Class Safety Man. Student's answers must be basically correct.

Criterion Test: The student will conform to the safety policies for the duration of his assignment to CE School.

Homework: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Safety Precautions.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Safety policies.	1. State information and materials necessary to guide student.	
2. Application.		
3. Summary.		
4. Questions.		
5. Assignment.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

II. Presentation.

- A. Safety policies.
  - 1. Safe handling and use of equipment.
    - a. Electric drills.
    - b. Digging tools.
    - c. Ladders.
    - d. Climbing gear.
    - e. Generators.
    - f. Transformers.
    - g. Electrical panels.
  - 2. Personal safety.
    - a. Climbing poles.
    - b. Working around electrical circuits.
    - c. Working around generating equipment.
  - 3. Fire hazards.
    - a. Smoking.
  - 4. Methods of reporting a fire.
    - a. Report to the instructor:
    - b. Report to the office.
    - c. Fire alarm box.

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

5. Methods of fighting fire.
    a. CO_2 bottle.
    b. Water.
    c. Sand.
6. First aid in the field/shop.
    a. Report to instructor.
    b. Dispensary.

B. Introduction of Class Safety Man.

III. Application.

A. Apply rules of safety throughout assignment to CE School.

IV. Summary.

A. Safe handling and use of equipment.

B. Personal safety.

C. Fire hazard.

D. Methods of reporting fire.

E. Methods of fighting fire.

F. First aid.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Pole Climbing Equipment and Techniques

Average Time: 2 Periods (Class), 9 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Programmed Instruction, Series 071/590, "Pole Climbing Techniques".
3. The Lineman's and Cableman's Handbook, 4th edition, Kurtz, McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Materials:

1. Lineman's kit of climbing equipment.
2. Hardhat and gloves.
3. File and gaff gauge.

D. Training Aids and Devices:

1. Films:

Terminal Objective: Upon completion of this unit of instruction the student will be able to select, adjust, and use pole climbing equipment to climb a 35 foot pole in accordance with the Programmed Instruction Series 071/590, "Pole Climbing Techniques".

Enabling Objectives: Upon completion of this topic the student will be able to identify, inspect, adjust, and perform maintenance on climbing equipment prior to climbing a 20 foot practice pole. Steps of procedure will be performed in accordance with the Programmed Instruction Series 071/590, "Pole Climbing Techniques" without error.

Criterion Test: The student will perform the required inspection, adjustment and maintenance procedures on pole climbing equipment, and use the proper climbing techniques to climb a 20 foot pole as outlined in the Programmed Instruction. All procedures will be executed 100% correct.

Homework: Read "The Lineman's and Cableman's Handbook", chapter 43, pp. 43-1 thru 43-20.

a. MC 8317 "Lifeline of the Lineman" (15 min.).

b. TF 11-2827 "Climbing and Working on Poles" (25 min.).

c. CL1-001 "Climbing with Confidence" (28 min.).

2. Climbing equipment display.

E. Training Aids Equipment:

1. 35mm Movie Projector.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Pole Climbing Equipment and Techniques.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
a. Use and care of pole climbing equipment.	I.B.1.a. Well maintained climbing gear is the lifeline of the lineman.	
b. Attain climbing knowledge and skill.	I.B.1.b. Climbing with confidence can only be done after some practice and strict observance of all safety rules.	
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Identify, inspect, adjust and perform maintenance on climbing equipment.	1. State information and materials necessary to guide student.	
2. Pole climbing practical performance.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Climbing equipment.		
1. Body belt.	II.A.1. Introduce body belt.	
a. Cushion section.	II.A.1.a. Identify parts.	
(1) Comfort.		
b. Tool saddle (tool loops).		
(1) Holds tools (no tools in center loop).	II.A.1.b.(1) Stress: To prevent spinal injury.	
c. D-rings.		
(1) Attachment points for the safety strap.		
d. Belt section.		
(1) Secures body belt to waist.		
2. Safety strap.	II.A.2. Introduce safety straps.	
a. Strap.	II.A.2.a. Identify parts.	
(1) Supports body in working position.		
b. Snap/keeper combination.		
(1) To attach safety strap to D-rings.		
c. Buckle assembly.		
(1) To adjust length of safety strap.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Climbers.	II.A.3. Introduce climbers.	
a. Leg irons (left and right).	II.A.3.a. Identify parts.	
(1) Adjustable.		
b. Ankle straps.		
(1) Secures leg irons to feet.		
c. Leg straps and pads.		
(1) Secures top of leg iron.		
d. Gaffs.		
(1) Steel (Tree or pole).		
(2) Replaceable spurs.		
(3) Supports body weight.		
4. Lineman's gloves.	II.A.4. Introduce gloves.	
a. Leather with gauntlets.		
b. Required hand and arm protection.		
5. Safety hat.	II.A.5. Introduce safety hat.	
a. High impact fiberglass with adjustable head band.		
b. Required head protection on job sites.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
B. Inspection.	II.B. Demonstrate inspection of belt, strap and climbers.	
1. Body belt, safety strap and climbers.		
a. Carefully inspect before each use.		
b. Check leather and/or fabric.		
(1) For cuts, cracks, tears, enlarged buckle tongue holes, and for hard or dry leather.		
(2) Stitching for broken, ragged, or rotten threads.		
c. Check metal parts.		
(1) For breaks, cracks, loose attachments and excessive wear.		
C. Adjustments.		
1. Body belt.		
a. Snug, but not tight.	II.C.1.a. Demonstrate proper position of belt on body.	
b. Approximately 2" below waistline, on the hips.		
2. Safety strap.	II.C.2. Demonstrate how to adjust safety strap.	
a. Length adjustable to meet working conditions.		
3. Climbers.	II.C.3. Demonstrate how to adjust climbers.	
a. Remove keeper screws.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Raise or lower sleeve approximately 1/2" below the inside prominence of the knee joint.		
c. Reinstall keeper screws.		
4. Safety hat.	II.C.4. Demonstrate safety hat head band adjustment.	
a. Head band must be tight enough to hold hat on head regardless of the working position.		
D. Maintenance.		
1. Leather parts.		
a. Clean with saddle soap every 3 months or as necessary.		
b. Dress with neats foots oil after cleaning, let dry 24 hours.		
2. Nylon parts.		
a. Clean with warm soapy water.		
3. Climbers.		
a. Check gaffs frequently with gaff gauge.	II.D.3.a. Demonstrate proper use of gaff gauge.	
b. Sharpen and shape as required.	II.D.3.b. Demonstrate how to sharpen a gaff.	
(1) Sharpen on flat side only.		
(2) Use 10" mill-bastard or 8" smooth file.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) File from heel to point.		
(4) Check progress with gauge.		
E. Films:	II.E. Show films and discuss highlights.	
1. MC-8317, "Lifeline of the Lineman".		
2. TF-11-2827, "Climbing and Working on Poles".		
3. CL1-001, "Climbing with Confidence".		
F. Pole climbing techniques.		
1. Programmed Instruction, "Pole Climbing Techniques".	II.F.1. Discuss and answer questions.	II.F.1. Participate in discussion.
2. "The Lineman's and Cableman's Handbook".		
G. Safety.		
1. Accident prevention.		
a. Causes of accidents.		
(1) Lack of supervision and/or knowledge.		
(a) Improper work methods.		
(b) Rules or instructions not observed.		
(c) Lack of proper inspection and maintenance. (Defective tools, materials and devices.)		
(2) Personal carelessness.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(a) Attitude.		
(b) Failure to think.		
(c) Mechanical manner of doing work (lack of concentration).		
(d) Haste.		
(e) Poor judgement.		
(f) Willfulness.		
(g) Physical condition.		
(h) Intoxication.		
(i) Conditions beyond control (elements).		
(j) Contributory negligence of others.		
III. Application.		
A. Student practice.	III.A. Provide climbing equipment and tools for each student.	
1. Wearing body belt and safety strap.		III.A.1. Put on body belt and safety strap and adjust for proper fit.
2. Adjusting climbers.		III.A.2. Adjust height of leg irons to within 1/2" of the knee joint.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Check climbers with gaff gauge, sharpen as required.	III.A.3. Closely observe students gauging and sharpening gaffs.	III.A.3. Sharpen gaffs as required.
4. Perform pole climbing procedure.	III.A.4. Demonstrate how to climb, maneuver and assume working positions on pole.	III.A.4. Observe instructor demonstration. a. Ask instructor to check for proper fit. b. Students perform practice climbing.

IV. Summary.

A. Climbing equipment.

B. Inspection.

C. Adjustments.

D. Maintenance.

E. Films.

F. Pole climbing techniques.

G. Safety.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: **Pole Climbing** Practice to Qualify

Average **Time**: 12 Periods (Pract)

Instructional **Materials**:

A. Texts: None

B. **References**: None.

C. Tools, **Equipment** and Materials:

1. Lineman's kit of climbing equipment.
2. Hardhat and gloves.
3. Practice poles.

D. Training Aids and Devices: None.

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit of instruction the student will be able to select, adjust, and use pole climbing equipment to climb a 35 foot pole in accordance with the Programmed Instruction Series 071/590, "Pole Climbing Techniques".

Enabling Objectives: Upon completion of this topic the student will be able to climb a 35 foot pole to within 2 feet of the top, belt off, circle the pole clockwise and counter-clockwise and descend to the ground. Steps of procedure will be performed without error in order to qualify for "Lineman".

Criterion Test: The student will climb a 35 foot pole, following the prescribed safety practices and steps of procedure as outlined in the Programmed Instruction, "Pole Climbing Techniques" without error.

Homework: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Pole Climbing Practice.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
a. To become proficient in pole climbing.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objective.	
1. Pole climbing practice.	1. State information and materials necessary to guide student.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Practice pole climbing.	II.A. Schedule practice at 1 hour per day for first 4 weeks.	
1. In accordance with Pole Climbing Techniques, Topic 1.2.1.		
III. Application.		
A. Perform pole climbing practice.		
1. Ascend a pole, belt-off, circle clockwise and counter-clockwise, unbelt, and descend.		
IV. Summary.		
A. Pole climbing practice.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: **Boxes, Fittings and Electrical Devices**

Average Time: 7 Periods (Class)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 7.
2. National Electrical Code, Article 370.

B. References:

1. American Electricians Handbook, 9th edition, Croft, Carr and Watt; McGraw-Hill Book Co., New York, N.Y.

C. Tools, Equipment and Materials:

1. Boxes, steel.
2. Boxes, Non-metallic.
3. Fittings.
4. Electrical devices.
5. Wall plates.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install boxes, and fittings within an open-framed building. Evaluation of this topic will be conducted during Topic CE "A" 1.3.13 and in accordance with the Job Sheet CE "A" JS 1.3.13.1 "Cubicle Wiring". Installation of electrical materials will be 100% correct.

Criterion Test: The student will install the required boxes, fittings and electrical devices in an open-framed building. Installation will be 100% correct.

Homework: Read Construction Electrician 3 & 2, chapter 7, pp. 167 - 176.

D. Training Aids and Devices:

1. Locally prepared materials:

    a. Electrical material display board.

    b. Information sheet.

        (1) CE "A" IS 1.3.1.1, "Boxes, Fittings and Electrical Devices".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Boxes, Fittings and Electrical Devices.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
a. Identify and use electrical material.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Boxes.	1. State information and materials necessary to guide student.	
2. Fittings.		
3. Electrical devices.		
4. Wall plates.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Boxes. 1. Steel. a. 4/S. b. 4/0. c. Handy. d. Gem.	II.A. Pass out information sheet CE "A" IS 1.3.1.1, "Boxes, Fittings and Electrical Devices".	
2. Non-metallic and metallic cast boxes.		
a. Non-metallic switch boxes. b. Conduit outlet bodies. c. FS and FD. d. Switch and outlet, with mounting nails.	II.A.2.a. Show the electrical material display board.	
3. Number of conductors (box fill).		
a. NEC Table 370-6(a)(1), "Deep Boxes". b. NEC Table 370-6(a)(2), "Shallow Boxes". c. NEC Table 370-6(b), "Volume Required Per Conductor".	II.A.3.a. Stress the need for code rulings governing electrical materials.	
B. Fittings.		

1. Conduit.

2. Cable.

3. Supports.

4. Covers.

C. Electrical devices.

1. Receptacles.

2. Switches.

3. Lampholders.

4. Surface-type wiring devices.

D. Wall plates.

1. Switches.

2. Receptacles.

3. Miscellaneous.

III. Application.

A. Student will select the proper electrical materials for installation into the 3-room cubicle in accordance with procedures outlined in Job Sheet CE "A" JS 1.3.13.1, "Cubicle Wiring".

IV. Summary.

1. Boxes.

2. Fittings.

3. Electrical Devices.

4. Wall plates.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Basic Circuits and Blueprints

Average Time: 7 Periods (Class), 1 Period (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 2.
2. National Electrical Code, Articles 210 and 220.
3. Programmed Instruction, Series 058/551A, "Electrical Symbols".
4. TM5-704, "Construction Print Reading in the Field", August 1952.

B. References:

1. American Electrician's Handbook, 9th edition, Croft, Carr and Watt; McGraw-Hill Book Co., New York, N.Y.

C. Tools, Equipment and Materials:

1. Paper.
2. Ruler.
3. Pencil.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to draw basic circuits and blueprints. Completed drawings will contain incandescent and flourescent lighting systems. Drawings will conform to the requirements outlined in the Information Sheet CE "A" IS 1.3.2.1, "Basic Circuits and Blueprints", and will be 100% correct.

Criterion Test: The student will complete an electrical drawing containing the required circuits for new construction without error.

Homework: Read Construction Electrician 3 & 2, chapter 2, pp. 12 - 25.

D. Training Aids and Devices:

1. Locally Prepared Material.

a. Information sheets.

(1) CE "A" IS 1.3.2.1, "Basic Circuits and Blueprints".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Basic Circuits and Blueprints.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
a. Draw electrical diagrams.		
2. Assignment.		
a. Complete electrical drawing.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Basic circuits, multiwire.	1. State information and materials necessary to guide student.	
2. Voltage.		
3. Grounding type receptacles and protection.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Conductors.		
5. Receptacle outlets.		
6. Feeders.		
7. Branch circuit and feeder calculations.		
8. Electrical prints.		
II. Presentation.		
A. Basic circuits, multi-wire.		
1. Definitions, NEC Article 100.		
2. Color code for branch circuits.		
3. Grounded conductor.		
4. Grounding conductor.		
5. Ungrounded conductor.		
6. Symbols.	II.A.6. Review P.I. 058/551A, "Electrical Symbols".	
B. Voltage.		
1. To ground.		
2. Between conductors - dwellings and non-dwelling occupancies.		
3. Voltage drop.		
C. Grounding-type receptacles and protection.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

D. Conductors.
  1. Insulation.
  2. Notes to Tables 310-12 through 310-15.
  3. Ampacity.

E. Receptacle outlets.
  1. Ground-fault circuit protection.
  2. Maximum load.
  3. Permissible load.

F. Feeders.

G. Branch-circuit and feeder calculations.
  1. General lighting load.
  2. Lighting and receptacle circuits.
  3. Continuous and non-continuous loads.

H. Electrical prints.
  1. Symbols.
  2. Scale.
  3. Floor plans.
  4. Wiring diagrams.
  5. Notes.

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OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

a. Mechanical.

b. Electrical.

III. Application.

A. The student will complete an electrical print in accordance with information sheets CE "A" IS 1.3.2.1, "Basic Circuits and Blueprints".

IV. Summary.

A. Basic circuits, multi-wire.

B. Voltage.

C. Grounding type receptacles and protection.

D. Conductors.

E. Receptacle outlets.

F. Feeders.

G. Branch circuit and feeder calculations.

H. Electrical prints.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Conductors, Splices and Connectors.

Average Time: 1 Period (Class), 1 Period (Pract)

Instructional Materials:

A. **Texts:**

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 7.
2. National Electrical Code, Article 310.

B. **References:**

1. American Electrician Handbook, 9th edition, Croft, Carr and Watt, McGraw-Hill Book Co., New York, N.Y.

C. **Tools**, Equipment and Materials:

1. Electrician's knife.
2. Adjustable open-end wrenches.
3. 1 foot lengths of #12 and #6 insulated conductors.
4. Wirenuts, Type HS-20.
5. Split-bolt connectors for #6 wire.
6. Electrical tape, plastic.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to make interior wiring splices and connections using insulated copper conductors, wirenuts, split-bolt connectors and electrical tape. Splices and connections will be made in accordance with the job sheet CE "A" JS 1.3.3.1, "Conductors, Splices and Connectors". Practical application will be 100% correct.

Criterion Test: The student will make splices and connections using 1 foot lengths of copper conductors and appropriate wirenuts and connectors. Splices and connections will be 100% correct.

Homework: Read Construction Electrician 3 & 2, chapter 7, pages 167 - 174.

D. Training Aids and Devices:

1. Splices and connections display.

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Conductors, Splices and Connectors.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview	I.D. State learning objectives.	
1. Conductors for general wiring.	1. State information and materials necessary to guide student.	
2. Splices and connectors used in interior wiring.		
3. Job sheet.		
4. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Conductors for general wiring.		
1. General description.		
a. NEC 310-1.		
2. Conductor application.	II.A.2. Stress: 300 volt insulation (limited to fixture wiring) 600 volt insulation (general wiring).	
a. NEC 310-2.		
(1) Table 310-2(a) Conductor application.		
3. Conductor insulations.	II.A.3. Compare: How insulation thickness varies between: Ex.-RHW and THWN.	
a. NEC Table 310-2(b) Conductor Insulations.		
4. Notes to NEC Tables 310-12 through 310-15.	II.A.4. Stress: Importance of Notes 1-12 when applied to interior wiring.	
B. Splices and connectors used in interior wiring.		
1. Splices.		
2. Connectors.		
C. Introduce job sheet.		
1. CE "A" JS 1.3.3.1, "Conductors, Splices and Connectors".		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
D. Steps of procedure.		
1. Make a splice using: two one foot lengths of #12 solid copper conductors and a #HS-20 wirenut.		
a. Prepare conductors by stripping 5/8" of insulation from one end of each wire.	II.D.1.a. Demonstrate: Technique of using electrician's knife to skin insulation.	II.D.1.a. Observe technique.
b. Grasp both wires together (with skinned ends even).	II.D.1.b. Note: Wires may be twisted together or straight.	
c. Place the wirenut over bare ends and turn in a clockwise direction until tight. (Completed splice shall have no bare copper exposed below the wirenut.)	II.D.1.c. Note: Size of wirenut will be dependent upon size and number of conductors.	
2. Make a splice using: two one foot lengths of #12 solid copper conductors, one one foot length of fixture wire, and a #HS-20 wirenut.		
a. Prepare conductors by stripping 5/8" of insulation from one end of the 2 #12 conductors.		
b. Skin 1" of insulation from one end of the fixture wire.		
c. Grasp the 2 #12 conductors and wrap (in a clockwise direction) the stranded fixture wire around the 2 #12's.	II.D.2.c. Ensure that the #12 conductors are even at the ends.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Turn the wirenut on to the 3 wires and twist in a clockwise direction until tight.		
3. Make a splice using: two one foot lengths of #6 stranded copper conductors and a #6 split-bolt connector.		
a. Prepare conductors by stripping 1" of insulation from one end of each conductor.		
b. Place stripped ends of conductors together and install #6 split-bolt connector.	II.D.3.b. Demonstrate: Proper procedure for disassembling #6 split-bolt connector and reassembling over the two #6 conductors.	
c. Tighten split-bolt connector using two adjustable open-end wrenches.	II.D.3.c. Demonstrate: Place one wrench on body of the connector and tighten bolt with second wrench.	II.D.3.c. Splice must not slip when pulled by hand.
d. Tape finished connection by applying plastic tape until original insulation is replaced.		
III. Application.		
A. Student practice.	III.A. Splices shall be 100% correct and no exposed bare copper.	
a. Make splices using wirenuts, split-bolt connectors and electrical tape.		
IV. Summary.		
A. Conductors for general wiring.		
B. Splices and connectors used in interior wiring.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

C. Job sheet.

D. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Code Studies

Average Time: 5 Periods (Class)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 7.

2. National Electrical Code, chapters 1, 2, 3, 4 and 9.

B. References: None.

C. Tools, Equipment and Materials: None.

D. Training Aids and Devices:

1. Locally Prepared Material:

a. Information sheet.

(1) CE "A" IS 1.3.4.1, "Code Studies".

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to select the correct code ruling that applies to each item of electrical material and equipment to be installed in the open-framed building and a reinforced concrete slab area with surrounding concrete masonry unit wall. Selections will be in accordance with the National Electrical Code and the Information Sheet CE "A" IS 1.3.4.1, "Code Studies". Code rulings selections will be 100% correct.

Criterion Test: The student will demonstrate his/her ability by selecting the correct code ruling that applies to the circuits and equipment to be installed during Topic 1.3.5 "Conduit Wiring", and Topic 1.3.12, "Cubicle Wiring". Selections will be 100% correct.

Homework: Read National Electrical Code, chapters 1 and 2.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Code Studies.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Introduction.	1. State information and materials necessary to guide student.	
2. General guides, chapter 1.		
3. Wiring design and protection, chapter 2.		
4. Wiring methods and materials, chapter 3.		
5. Equipment for general use, chapter 4.		
6. Tables and examples, chapter 9.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

II. Presentation.

- A. Introduction.
  - 1. Purpose of code.
  - 2. Scope.
  - 3. Examination of equipment for safety.
  - 4. Wiring planning.
- B. General guides, chapter 1.
  - 1. Definitions.
  - 2. General requirements.
- C. Wiring Design and Protection, chapter 2.
  - 1. Use and identification of grounded conductors.
  - 2. Branch circuits.
  - 3. Feeders.
  - 4. Branch-circuit and feeder calculations.
  - 5. Articles.
  - 6. Overcurrent protection.
  - 7. Grounding.
- D. Wiring methods and materials.
  - 1. General requirements.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

2. Conductors for general wiring.

3. Non-metallic-sheathed.

4. Rigid metal conduit.

5. Rigid non-metallic conduit.

6. Electrical metallic tubing.

7. Outlet, switch and junction boxes and fittings.

8. Switches.

9. Switchboards and panelboards.

E. Equipment for general use, chapter 4.

1. Lighting fixtures, lampholders, lamps, receptacles and rosettes.

2. Motors, motor circuits and controllers.

F. Tables and examples.

1. Tables and notes.

2. Examples of service calculations.

III. Practical application.

A. The student will apply the code rulings during the practical application of Topics 1.3.5 and 1.3.12.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

IV. Summary.

- A. Introduction.
- B. General Guides, chapter 1.
- C. Wiring Design and Protection, Chapter 2.
- D. Wiring Methods and Materials.
- E. Equipment for General Use, Chapter 4.
- F. Tables and Examples.

V. Test: None.

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NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Conduit Installation

Average Time: 2 Periods (Class), 12 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 7.

2. National Electrical Code, Articles 346 and 348.

B. References:

1. American Electrician's Handbook, 9th edition, Croft, Carr and Watt; McGraw-Hill Book Co., New York, N.Y.

C. Tools, Equipment and Materials:

1. Electrician's tool kit.

2. Hand benders (E.M.T.), sizes 1/2" and 3/4".

3. Greenlee ratchet bender, 1/2" to 1"

4. Rigid steel conduit.

5. Rigid non-metallic conduit.

6. Rigid non-metallic conduit bender.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install rigid metal conduit, rigid non-metallic conduit and electrical metallic tubing. Installation will be performed in a reinforced concrete slab area with surrounding concrete masonry unit wall in accordance with the job sheet CE "A" JS 1.3.5.1, "Conduit Installation in Concrete Slab and Cinder Block Wall". Conduit runs will be installed 100% correct.

Criterion Test: The student will install rigid steel conduit, rigid non-metallic conduit and electrical metallic tubing in the reinforced concrete. Installation will be 100% correct.

Homework: Read National Electrical Code, articles 346 and 348 and Construction Electrician 3 & 2, pages 161 - 166.

7. Electrical metallic tubing.

8. Connectors, E.M.T.

9. Locknuts.

10. Bushings.

D. Training Aids and Devices:

1. Films:

   a. TF-6037, "Conduit Installation" (17 min.), Color, 67, AF.

   b. OE-382, "Power Conduit Bending" (17 min.).

2. Locally Prepared Material.

   a. Conduit display board.

   b. Job sheet.

      (1) CE "A" JS 1.3.5.1, "Conduit Installation in Concrete Slab and Cinder Block Wall".

   b. Information sheet.

      (1) CE "A" IS 1.3.5.1, "Under-slab Conduit Installation".

E. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Conduit Installation		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of materials being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Rigid steel conduit.	1. State information and materials necessary to guide student.	
2. Rigid non-metallic conduit.		
3. Electrical metallic tubing.		
4. Job sheet.		
5. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Rigid steel conduit.		
1. Use.		
2. Cinder fill.		
3. Minimum size.		
4. Number of conductors in conduit.		
5. Cut, ream and thread.	II.A.5. Stress: Why these procedures as listed must be followed.	
6. Bushings, couplings and connectors.		
7. Bends.		
a. How made.		
b. Number in one run.		
8. Supports.		
9. Construction specifications.		
10. Film; "Power Conduit Bending".	II.A.10. Show film and discuss highlights.	
B. Rigid non-metallic conduit.		
1. Description.		
2. Uses permitted		
3. Uses not permitted.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Installation requirements.	II.B.4. Demonstrate bending PVC with approved bender.	
a. Trimming.		
b. Joints.		
c. Supports.		
d. Expansion joints.		
e. Number of conductors.		
f. Bends, how made.		
g. Bends, number in one run.		
h. Boxes and fittings.		
i. Splices and taps.		
5. Construction specifications.		
C. Electrical Metallic tubing.		
1. Use.		
2. Wet locations.		
3. Minimum and maximum sizes.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Number of conductors in tubing.		
5. Couplings and connectors.		
6. Bends.		
a. How made.		
b. Number in one run.		
7. Cutting and reaming.	II.B.7. Stress: The need to ream E.M.T. to avoid damage to conductor insulation.	
8. Supports.		
9. Construction specifications.		
10. Film: "Conduit Installation".	II.B.10. Show film and discuss highlights.	II.B.10. View film and participate in discussion.
C. Introduce job sheet.		
1. CE "A" JS 1.3.5.1, "Conduit Installation in Concrete Slab and Cinder Block Wall".		
D. Steps of procedure.		
1. Install rigid conduit (steel or P.V.C.) into a reinforced concrete slab.	II.D.1. Note: Assign a conduit run to two students. Pass out job sheet CE "A" JS 1.3.5.1 and information sheet CE "A" IS 1.3.5.1.	
a. Locate stub-up points on print.		
b. Measure distance of conduit run on print and convert to working measurements.	II.D.1.b. Stress: Scale on print 3/8" = one foot. 3/8" = distance on print. one foot = actual distance applied to conduit run.	
c. Locate conduit run with stakes and chalk.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Select preformed sections of conduit for assigned circuit. (Lighting, receptacle or special purpose.)		
e. Install conduit where indicated with chalk.		
f. Secure conduit to rebar at approximately every 3 feet with rebar tie-wire.		
g. Apply conduit section from conduit run (in the slab) to panel. Secure to panel with double lock-nuts and bushing.		
h. Apply conduit section from conduit run to junction box. Secure to J.B. with double lock-nuts and bushing.	II.D.1.h. Note: Plug both ends of conduit run with paper or rags to avoid any foreign matter that may be inserted.	
i. P.V.C. runs located in the slab will require rigid steel 90° stub-ups to panel and junction boxes.	II.B.1.i. Note: Installations shall be 100% correct.	
2. Install electrical metallic tubing.		
a. Measure distance of E.M.T. run between junction boxes as outlined on the print. Convert distance to working measurement.		
b. Select the proper size and length of E.M.T. and secure to the junction boxes with connectors and lock-nuts.	II.B.2.b. Note: Securing the E.M.T. to the junction boxes will secure the conduit into position.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Check all points of connection between conduit-to-panel, conduit-to-conduit and conduit-to-junction boxes.	II.B.2.c. Note: E.M.T. installations shall be 100% correct.	
III. Practical application.		
A. The student will install the following:		
1. Rigid conduit runs in the simulated reinforced concrete slab.		
2. Electrical metallic tubing runs in the concrete block wall surrounding the concrete slab.		
IV. Summary.		
A. Rigid steel conduit.		
B. Rigid non-metallic conduit.		
C. Electrical metallic tubing.		
D. Job sheet.		
E. Questions.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Non-metallic-Sheathed Cable

Average Time: 2 Periods (Class)

Instructional Materials:

A. Text:

1. National Electrical Code, Article 336.

B. References:

1. American Electrician's Handbook, 9th edition, Croft, Carr and Watt; McGraw-Hill Book Co., New York, N.Y.

C. Tools, Equipment and Materials:

1. Short lengths of all types of non-metallic-sheathed cables.

D. Training Aids and Devices:

1. Films:

   a. TF-6027, "Roughing-in Non-metallic-Sheathed Cable" (15 min.), Color, 67, AF.

   b. OE-377, "Cable Surface Wiring" (15 min).

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install non-metallic-sheathed cable in the open-framed building. Installation of Type "NM" cable will be performed during Topic CE "A" IG 1.3.12 and in accordance with the job sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Cable runs will be installed 100% correct.

Criterion Test: The student will install non-metallic-sheathed cable within an open-framed building. Installation will be 100% correct.

Homework: Read National Electrical Code, Article 336.

2. Locally Prepared Material:

   a. Non-metallic-sheathed cable circuits display board.

E. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Non-metallic-Sheathed Cable		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Non-metallic-sheathed cable.	1. State information and materials necessary to guide student.	
2. Practical application.		
3. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Non-metallic-sheathed cable.		
1. Definition.		
2. Construction.		
a. Type "NM".		
b. Type "NMC".		
c. Marking.		
3. Use.		
a. Type "NM".		
b. Moisture and corrosion-resistant Type "NMC".		
4. Supports.		
a. Exposed work.		
b. Through studs, joists and rafters.		
c. Bends.		
5. Films:		
a. OE-377, "Cable surface Wiring".	II.A.5. Show films and discuss highlights.	II.A.5. View films and participate in discussion.
b. TF-6027, "Rough-in Non-metallic Sheathed Cable".		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Practical application.		
A. Install non-metallic-sheathed cable in accordance with the job sheet CE "A" JS 1.2.12.1, "Cubicle Wiring" during Topic 1.3.12.		
IV. Summary.		
A. Non-metallic-sheathed cable.		
B. Films.		
C. Practical application.		
D. Questions.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Service Entrances

Average Time: 2 Periods (Class)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 7.
2. National Electrical Code, Article 230.

B. References:

1. American Electrician's Handbook, 9th edition, Croft, Carr and Watt, McGraw-Hill Book Co., New York, N.Y.

C. Tools, Equipment and Material: None.

D. Training Aids and Devices:

1. Locally Prepared Material.
    a. Service entrance display board.

E. Training Aids Equipment: None

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical materials and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install a single-phase, three-wire, 120/208 volt service for the interior wiring system in the open-framed building. Installation of the service will be done during Topic 1.3.12 and in accordance with the Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Service entrance installation will be 100% correct.

Criterion Test: The student will install a service entrance with associated equipment and devices. Installation will be 100% correct.

Homework: Read Construction Electrician, chapter 7, pages 157 - 160 and National Electrical Code, Article 230.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Service Entrances.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Definitions.	1. State information and materials necessary to guide student.	
2. Types of services.		
3. General requirements.		
4. Insulation and size of service conductors.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

5. Service drops.
6. Underground services.
7. Service-entrance conductors.
8. Service equipment.
9. Grounding and Guarding.
10. Practical application.
11. Questions.

II. Presentation.

A. Definitions.

1. Service.
2. Service cable.
3. Service conductors.
4. Service drop.
5. Service entrance conductors.
   a. Overhead system.
   b. Underground system.
6. Service equipment.
7. Service lateral.
8. Service raceway.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

B. Types of services.
   1. Single phase, 2-wire.
   2. Single phase, 3-wire.
   3. Three phase, 4-wire.
   4. Three phase, 3-wire.

C. General requirements.
   1. Residential.
   2. Emergency lighting.
   3. Multiple-occupancy buildings.
   4. Sub-sets of service entrance conductors.

D. Insulation and size of service conductors.

E. Service drops.
   1. Service-drop conductors.
   2. Minimum size.
   3. Clearances.
   4. Supports over buildings.
   5. Point of attachment.
   6. Means of attachment.

- F. Underground services.
    - 1. Insulation.
    - 2. Size.
    - 3. Protection against damage.
    - 4. Raceway seal.
- G. Service-entrance conductors.
    - 1. Conductors without splice.
    - 2. Other conductors in service raceway.
- H. Service equipment.
- I. Grounding and Guarding.

III. Practical Application.

- A. Shall be performed during Topic 1.3.12.

IV. Summary.

- A. Definitions.
- B. Types of service.
- C. General requirements.
- D. Insulation and size of service conductors.
- E. Service drops.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

F. Underground service.

G. Service-entrance conductors.

H. Service equipment.

I. Grounding and Guarding.

J. Practical application.

K. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Light Fixtures

Average Time: 2 Periods (Class)

Instructional Materials:

A. Texts:

   1. National Electrical Code, Article 410.

B. References:

   1. American Electrician's Handbook, 9th edition, Croft, Carr and Watt; McGraw-Hill Book Co., New York, N.Y.

C. Tools, Equipment and Materials: None.

D. Training Aids and Devices:

   1. Locally Prepared Material:

      a. Flourescent and Incandescent Lighting Display.

      b. Information sheet.

         (1) CE "A" IS 1.3.8.1, "Light Fixtures".

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install flourescent and incandescent lighting fixtures in the open-framed building. Installation of fixtures will be done during Topic 1.3.12 and in accordance with the job sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Fixtures will be installed 100% correct.

Criterion Test: The student will install flourescent and incandescent lighting fixtures. Installation will be 100% correct.

Homework: Read National Electrical Code, Article 410.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Light Fixtures.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Incandescent lighting.	1. State information and materials necessary to guide student.	
2. Flourescent lighting.		
3. Fixture wiring.		
4. Practical application.		
5. Questions.		

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

II. Presentation.

A. Incandescent lighting.

1. General rules.

a. NEC 410-1.

2. Provisions for fixture locations.

a. NEC 410-4, Specific Locations.

b. NEC 410-5, Near Combustible Material.

c. NEC 410-6, Over Combustible Material.

d. NEC 410-8, In Clothes Closets.

3. Provisions at fixture outlet boxes, canopies and pans.

a. NEC 410-11, Temperature Limit of Conductors at Outlet Boxes.

4. Fixture supports.

a. NEC 410-15, Supports, General.

b. NEC 410-16, Means of Support.

5. Wiring of fixtures.

a. NEC 410-17, Fixture Wiring - General.

b. NEC 410-19, Conductor Insulation.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

- c. NEC 410-23, Protection of Conductors and Insulation.
- d. NEC 410-26, Fixture Raceways.
- e. NEC 410-27, Polarization of Fixtures.

6. Installation of lampholders.
    - a. NEC 410-41, Screw-shell Type.
    - b. NEC 410-43, Lampholders in Damp or Wet Locations.
7. Lamps.
    - a. NEC 410-49, Bases, Incandescent Lamps.

B. Flourescent lighting.

1. Fixture mounting.
    - a. NEC 410-74, Fixture Mounting.
        - (1) Exposed ballasts.
        - (2) Combustible low-density cellulose fiberboard.
2. Grounding.
    - a. NEC 410-92, Metallic Wiring Systems.
    - b. NEC 410-93, Non-Metallic Wiring Systems.
    - c. NEC 410-95, Equipment Near Grounded Surfaces.
    - d. NEC 410-96, Methods of Grounding.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
C. Fixture wiring.		
1. Incandescent and flourescent.		
a. Introduce information sheet.	II.C.1.a. Pass out information sheet CE "A" IS 1.3.8.1, "Light Fixtures".	
(1) CE "A" IS 1.3.8.1, "Light Fixtures".		
III. Practical application.		
A. Installation of lighting fixtures will be executed during the cubicle wiring practical in accordance with CE "A" JS 1.3.12.1, "Cubicle Wiring".		
IV. Summary.		
A. Incandescent lighting.		
B. Flourescent lighting.		
C. Fixture wiring.		
D. Practical application.		
E. Questions.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Temporary Wiring

Average Time: 1 Period (Class), 5 Periods (Pract)

Instructional Materials:

A. Texts:

1. National Electrical Code, Articles 210 and 305.

B. References: None.

C. Tools, Equipment and Materials:

1. Electrician's tool kit.
2. Digging tools.
3. Temporary power pole assembly - 50 amp.
4. Temporary power panel and cord assembly - 50 amp.
5. 5 foot step ladder.
6. 20 foot extension ladder.
7. 1/2" rigid steel conduit.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install a pole-mounted temporary wiring system required for new construction. Installation will conform to the drawings and procedures outlined in the job sheet CE "A" JS 1.3.9.1, "Temporary Wiring". Installation will be 100% correct.

Criterion Test: The student will install a temporary wiring system in accordance with drawings and procedures outlined in the job sheet CE "A" JS 1.3.9.1, "Temporary Wiring". Installation will be 100% correct.

Homework: Read National Electrical Code, Articles 210 and 305.

8. Grounding conductor, #8 AWG bare copper.

9. 8 foot x 5/8" copper-weld ground rod.

D. Training Aids and Devices:

1. Locally Prepared Material.

   a. Job sheet.

      (1) CE "A" JS 1.3.9.1, Temporary Wiring".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Temporary Wiring.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Temporary wiring.	1. State information and materials necessary to guide student.	
2. Introduce job sheet.		
3. Steps of procedure.		
4. Practical performance.		
5. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Temporary wiring.		
1. General requirements.		
a. Services.		
b. Feeders.		
c. Branch circuits.		
d. Receptacles.		
e. Earth returns.		
f. Disconnecting means.		
2. Ground fault protection.	II.A.2. Stress the need for NEC Articles 210-7 and 305.	
a. Grounding-type receptacles and protection.		
3. Types.		
a. Temporary power pole assembly.	II.A.3.a. Describe the panels with their receptacles and circuit protection.	
(1) 50 amp capacity.		
b. Temporary power panel and cord assembly.		
(1) 50 amp capacity.		
4. Temporary service requirements.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Clearance above ground service drop "minimum clearances".		
(1) At center of street . . . . .18'		
(2) At curb line . . . . .16'		
(3) Over residential driveway . .12'		
b. Normal height of pole.	II.A.4.b. A longer pole shall be used where normal height pole will not provide required clearance.	
(1) 25' - 6" x 6".		
c. Conduit and fittings.		
(1) Minimum conduit size - 3/4".		
(2) Galvanized rigid steel or aluminum conduit, electrical metallic tubing or polyvinyl chloride schedule 80 plastic conduit without protective covering. Metal conduit shall be covered with wood moulding or fiber conduit.		
(3) Conduit fittings shall be raintight.		
(4) Wire with rubber or equivalent insulation shall be not less than No. 8 AWG.		

(5) Receptacles shall be of proper rating for the load to be served, for portable tools - 3-pole type. For single phase and three phase motors - 4-pole type. Where more than one voltage is used, receptacles shall not be interchangeable.

d. Grounding.

(1) Armored ground wire no. 8 min., ground wire.

(2) Approved grounding clamp and fittings must be accessible. Conduit must extend to ground rod to protect ground wire from mechanical injury.

B. Introduce job sheet.

1. CE "A" JS 1.3.9.1, "Temporary Wiring".

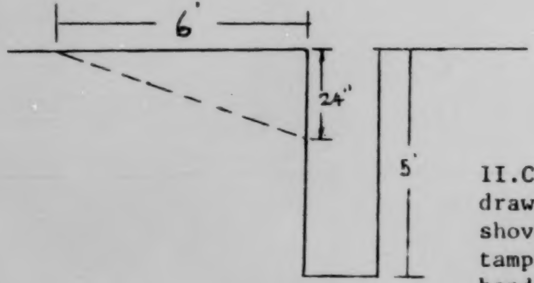
C. Steps of procedure.

1. Install temporary power pole assembly.

a. Location of pole shall be 18' north of northwest corner of the "conduit-wiring-in-slab area" building.

b. Use appropriate digging tools and dig a 12" diameter by 5' minimum deep hole with a sloping trench to the hole approximately 6' long by 10" wide.

II.C.1. on chalkboard.



II.C.1.b. Student will draw digging tools: shovel (D-handle), tamping bar, long handle shovel, and scoop shovel.

OUTLINE OF INSTRUCTION — INSTRUCTOR ACTIVITY — STUDENT ACTIVITY

c. Use 2" x 10" x 8' butt board in the hole.

d. With the pre-assembled pole butted up against the butt board, in the sloping trench, two men on each side of the pole will raise and set the assembly into the hole.

e. Four men, each positioned 90° apart around the pole, will support the pole in a vertical position with pike poles.

f. One shoveler and one tamper; replace all the dirt back in the hole around the pole.

2. Install grounding system.

   a. Select an 8' x 5/8" copper weld ground rod and position it approximately 12" to the right side of the pole while facing the panel.

   b. Use a 5 foot step ladder for required height when hammering ground rod into the ground.

   c. Select the pre-formed 1/2" rigid steel conduit with threaded ends and one 90° bend.

   d. Install ground clamp assembly on the 90° end.

   e. Secure straight end to knockout in panel with double-locknut and bushing.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
f. Secure ground clamp to ground rod.		
g. Install #8 AWG bare copper conductor and connect to neutral bar in the panel and to ground clamp.		
h. Secure 1/2" conduit with 2 1/2" rigid steel conduit straps. (Use wood screws.)		
3. Connect service drop to building 120.		
a. Position 20 foot extension ladder against rear of building.	II.C.3.a. Ensure that ladder is positioned at the proper angle before student ascends.	
b. Secure the 3 #8 insulated conductors (from the temporary power pole) to the insulator rack attached to the building.		
c. Ensure that the service power is "OFF" before making the 3 connections.		
4. Test circuits.		
a. Connect extension cord with required twist-lock, 3 prong plug and check cord assembly outlet with a Wiggin's voltage tester.		
b. Using a 40 watt lightbulb and test socket, connect one lead to hot terminal of receptacle. Touch other lead of test light to ground.	II.C.4.b. Circuit breaker (ground fault circuit interrupter) will trip immediately to indicate proper operation of mechanism.	

LINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	EVALUATION: Depth of pole in ground, vertical positioning, installation of grounding system, connections at panel and building 120, and testing procedures shall be 100% correct.	

III. Practical performance.

A. The student will dig a hole and set a temporary power pole using appropriate tools and equipment. Installation and testing will be in accordance with CE "A" JS 1.3.9.1, "Temporary Wiring".

IV. Summary.

A. Temporary wiring.

B. Introduce job sheet.

C. Steps of procedure.

D. Practical performance.

E. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Hand Tools and Test Equipment

Average Time: 2 Periods (Class), 3 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 4.
2. Tools and Their Uses, NAVPERS 10085-B.

B. References: None.

C. Tools, Equipment and Materials:

1. Electrician's tool kit.
2. Ammeter.
3. Voltmeter.
4. Multimeter (Simpson 260).
5. Clamp-on Volt-ammeter.
6. A.C. power-circuit analyzer.
7. Phase-sequence meter.
8. Voltage tester (Wiggins).

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to use handtools and test equipment required to install and test electrical equipment. Steps of procedure will be conducted at an assigned test bench in accordance with the job sheet CE "A" JS 1.3.10.1, "Handtools and Test Equipment". Use of handtools and testing will be executed 100% correct.

Criterion Test: The student will use tools and test equipment to install and check circuits for grounds, shorts, continuity, volts and amps. Testing procedures will be 100% correct.

Homework: Read Construction Electrician 3 & 2, chapter 4, pages 41 - 59.

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9. Non-metallic-sheathed cable.

10. Electrical metallic tubing.

11. Boxes, fittings and devices.

12. Assorted space heaters.

D. Training Aids and Devices:

1. Locally Prepared Material:

a. Job sheet.

(1) CE "A" JS 1.3.10.1, "Handtools and Test Equipment".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Handtools and Test Equipment		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Electrician's tool kit.	1. State information and materials necessary to guide student.	
2. Ammeter.		
3. Voltmeter.		
4. Multimeter (Simpson 260).		
5. Clamp-on volt-ammeter.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

6. A.C. power-circuit analyzer.

7. Phase-sequence meter.

8 Voltage tester (Wiggins).

9. Common power tools.

10. Practical application.

11. Questions.

II. Presentation.

A. Ammeter.

1. Description.

a. Internal components.

b. Dial.

2. Use.

3. Safety precautions.

B. Voltmeter.

1. Description.

a. Internal components.

b. Dial.

2. Use.

3. Safety precautions.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
C. Multimeter (Simpson 260).		
1. Description.		
a. Ammeter, (milliamps).		
b. Voltmeter, (A.C. or D.C.).		
c. Ohmmeter.		
d. Dial.		
2. Uses.		
3. Safety precautions.		
a. Do not use on interior wiring systems to check current.		
D. Clamp-on volt-ammeter.		
1. Description.		
2. Uses.		
3. Safety precautions.		
E. A.C. power-circuit analyzer.		
1. Description.	II.E.1. Construction Electrician 3 & 2, NAVPERS 10636-G, pages 45 - 51.	
2. Uses (direct readings).		
a. Single-phase, 2 wire circuit.		
b. Three-phase, 3 wire circuit.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Safety precautions.		
F. Phase-sequence meter.		
1. Description.	II.F.1. Construction Electrician 3 & 2, NAVPERS 10636-G, pages 57 - 58.	
2. Use.		
3. Hook-up procedures.		
G. Voltage tester (Wiggins).		
1. Description.	II.G.1. Construction Electrician 3 & 2, NAVPERS 10636-G, pages 52 - 53.	
2. Use.		
3. Testing procedures.		
4. Safety precautions.		
H. Common handtools.		
1. Safety rules.		
2. Electrician's tool box.		
I. Common power tools.		
1. Safety rules.		
2. Grounding requirements.		
3. Electric drill.		
4. Drill press.		

5. Bench grinder.

6. Disc sander - special safety precautions.

J. Introduce job sheet.

1. CE "A" JS 1.3.10.1, "Handtools and Test Equipment".

K. Steps of procedure.

1. Test an interior wiring system for continuity using the voltage tester (Wiggins).

a. Main disconnect - with the breaker in the OFF position, place the test leads on the incoming line leads L_1 and L_2. Voltage reading shall be approximately 220 volts.

b. Place the main disconnect and all circuit disconnects into the ON position. IF any circuit disconnect trips to the tripped position, make note of the circuit for further testing.

c. Check the remaining circuits for continuity by using the following procedures:

II.K.1.c. If lighting circuit feed goes to the lighting fixture first, then start at the fixture.

(1) Lighting circuit - Check hot lead to ground at lighting fixture (115 V.). Turn wall switch ON and check voltage to ground on both terminals of switch. Should indicate 115V.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Receptacle circuit - at each outlet check between each contact point and ground. 115V should be read between the smaller of the two parallel slots and ground.	II.K.1.c.(2) Stress: The smaller of the two parallel slots in the receptacle is the hot terminal.	
2. Locate a ground in the circuit (with the tripped breaker) using an ohmmeter.	II.K.2. Stress: Definition of the following:	
a. Ensure that all circuit breakers are OFF, including the main.	a. Short - Two wires in a cable or conduit making direct contact with each other	
b. Disconnect circuit from panel by removing circuit breaker with conductor attached.	b. Ground - A conductor making direct contact with metallic junction boxes or raceways.	
c. Remove circuit neutral conductor from neutral bar.		
d. Place test leads on the neutral conductor and ground. If a zero reading is obtained, the neutral is grounded somewhere in the circuit.	II.K.2.d. On a lighting circuit, ensure that all light switches are in the ON position and all light bulbs taken out of their sockets.	
e. Open circuit at the half-way junction box and determine which section is grounded.		
f. Continue process of elimination until grounded conductor is located.	II.K.2.f. At all points of testing, use test leads between the neutral or circuit conductor (whichever is grounded) and any metal portion of the circuit.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Locate a short in a second circuit (with a tripped breaker) using an ohmmeter.		
a. Ensure that all circuit breakers are OFF, including the main.		
b. Disconnect circuit from panel by removing circuit breaker with conductor attached.		
c. Remove circuit neutral conductor from neutral bar.		
d. Place test leads on neutral conductor and the lead connected to the circuit breaker. Meter will read ZERO if a short exists.	II.K.3.d. Ensure that all light bulbs are removed.	
e. Open circuit at the half-way junction box and determine which section is shorted.		
4. Repair grounded and shorted circuits.		
a. Correct the grounded and the shorted condition in each circuit with several wraps of electrical tape.	II.K.4.a. Test procedures and cable repairs shall be executed 100% correctly.	
b. Energize circuits by placing the main breaker and lighting and receptacle circuit breakers in the ON position.		
c. Test all circuits for normal operation.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

III. Application.

A. Practical performance.

1. The student will perform various tests on circuits using the voltage tester (Wiggins) and the ohmmeter. All tests will be done in accordance with job sheet CE "A" JS 1.3.10.1, "Handtools and Test Equipment".

IV. Summary.

A. Ammeter.

B. Voltmeter.

C. Multimeter (Simpson 260).

D. Clamp-on volt-meter.

E. A.C. power-circuit analyzer.

F. Phase-sequence meter.

G. Voltage tester (Wiggins).

H. Common handtools.

I. Common power tools.

J. Job sheet.

K. Questions.

L. Practical performance.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Motors, Motor Controllers and Circuits

Average Time: 6 Periods (Class)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G.
2. National Electrical Code, Article 430.
3. Allen-Bradley Manual, "Wiring Diagrams for Full-Voltage Starting Switches".

B. References: None.

C. Tools, Equipment and Materials:

1. Electrician's tool kit.
2. Motor.
3. Motor Controller.
4. Push button stop-start station.
5. Electrical metallic tubing.
6. #12 AWG insulated copper conductor.
7. Flexible conduit.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install a motor, motor controller and associated circuits within the open-framed building. Installation will take place during Topic 1.3.12 and in accordance with the job sheet CE "A" JS 1.3.12.1, "Cubicle Wiring". Equipment will be installed 100% correct.

Criterion Test: The student will install a motor and motor controller with a push button stop-start station. Installation will be without error and in accordance with job sheet CE "A" JS 1.3.12.1, "Cubicle Wiring".

Homework: Read National Electrical Code, Article 430.

D. Training Aids and Devices:

1. Films:

   a. OE-386, "Split-Phase Motor Principles" (20 min.).

   b. TF-6180, "Motor Control Systems" (16 min.).

   c. TF-5660, "Motor Connections in Three Phase and Single Phase Induction Motors" (20 min.).

2. Locally Prepared Materials:

   a. Cutaway of single phase A.C. motor.

   b. Disassembled three phase motor.

   c. Motor controller display.

   d. Information sheets.

      (1) CE "A" IS 1.3.11.1, "Single Phase Motors".

      (2) CE "A" IS 1.3.11.2, "Three Phase Motors".

      (3) CE "A" IS 1.3.11.3, "Motor Control".

E. Training Aids Equipment:

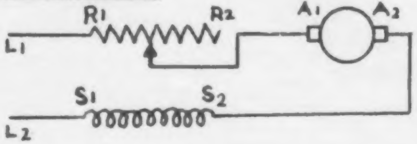
1. 16mm movie projector.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

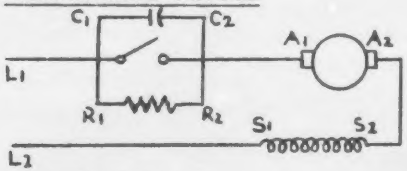
(6) Three methods of speed control - resistance, centrifugal device, tapped field.

II.A.1.a.(6) Draw on chalkboard

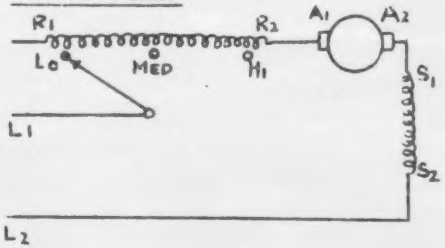
RESISTANCE


R1
R2
A1
A2
L1
S1
S2
L2

CENTRIFUGAL DEVICE


C1
C2
A1
A2
L1
R1
R2
S1
S2
L2

TAPPED FIELD


R1
R2
A1
A2
Lo
MED
Hi
S1
L1
S2
L2

B. Single-phase induction motors.

1. Types and characteristics.

a. Shaded pole.

(1) Stator-wound coils and solid shading coils.

II.B.1.a.(1) Shading coil - is starting winding, wound coils are running windings.

OUTLINE OF INSTRUCTION

(2) Rotor-squirrel cage.

(3) Reversing - not normally done due to amount of work required to reposition shading coils.

b. Straight-split phase.

(1) Stator - slotted for starting and running windings.

(2) Rotor squirrel cage.

(3) Centrifugal switch - disconnects starting winding from circuit.

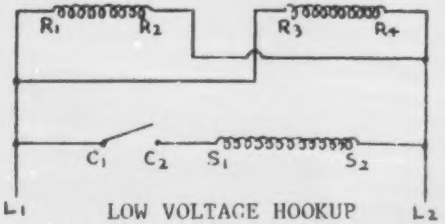
INSTRUCTOR ACTIVITY

II.B.1.b.(1) Display straight split-phase stator.

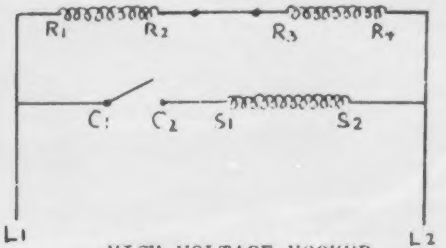
II.B.1.b.(3) Draw on chalkboard and show LO and HI-voltage connections.

Dual voltage - 2 running windings.

Single voltage - 1 running winding

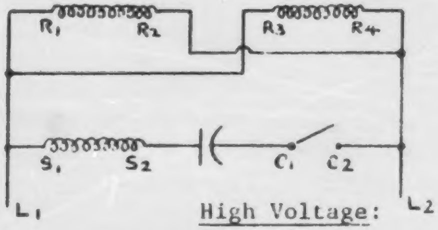
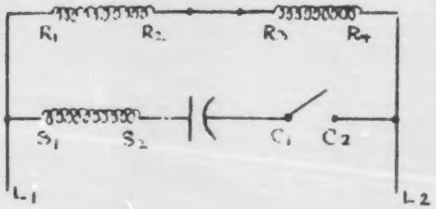


LOW VOLTAGE HOOKUP



HIGH VOLTAGE HOOKUP

STUDENT ACTIVITY

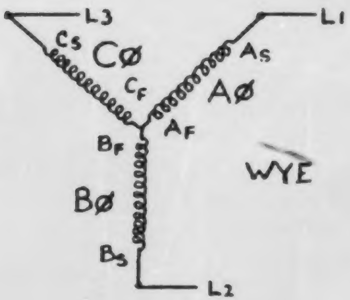
OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(4) Reversing - Reverse current flow through either starting or running winding, but not both.	II.B.1.b.(4) Show on chalkboard - on II.B.1.b.(3) drawing.	
(5) Used on oil burners, washing machines, pumps and bench grinders.		
c. Capacitor-start split-phase motor.		
(1) Same as straight split-phase with capacitor added for starting under full load.	II.B.1.c.(1) Define examples of no-load and full-load starting: No-load: Bench grinder. Full load: Compressor. Draw on chalkboard.	
(2) Connections - LO and HI voltage.	II.B.1.c.(2) Low Voltage:  High Voltage: 	

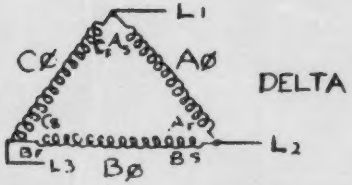
OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Used in refrigerators, compressors, buffers and floor sanders.		
d. Film: OE-386, "Split-phase Motor Principles".	II.B.1.d. Discuss highlights of film.	
C. Three-phase motors.		
1. Types and characteristics.		
a. Single voltage motor.	II.C.1.a. Display disassembled three-phase motor.	
(1) Stator - slotted for windings, three individual phases identified - A, B, C.		
(2) Rotor - squirrel cage.		
(3) Reversing - Reverse any two (2) line leads.		
(4) Connections - only three leads are "brought-out" to connect motor to L_1, L_2 and L_3.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(5) Three-phase single-voltage schematics.

II.C.1.a.(5) Draw on chalkboard.


L3
Cs
CØ
CF
BF
BØ
BS
L2
AF
AØ
AS
L1
WYE


L1
CØ
AS
AØ
DELTA
CS
AF
L2
BF
L3
BØ
BS

II.C.1.a.(5) Complete connections on information sheet CE "A" IS 1.3.11.2, "Three-Phase Motors".

b. Dual voltage.

(1) Same as a single-voltage motor except each phase is split and nine leads are brought out for high or low voltage connections.

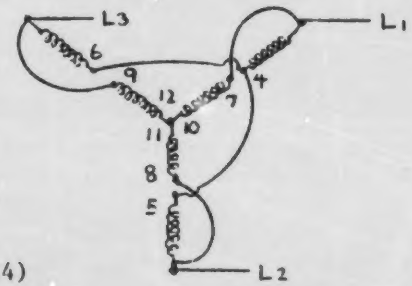
(2) Schematics.

II.C.1.b.(2) draw on chalkboard.

II.C.1.b.(2) Complete on information sheet, CE "A" IS 1.3.11.2, "Three-Phase Motors".

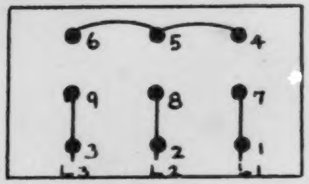
(a) Wye low-voltage connections.

Wye low-voltage


L3
6
9
12
7
4
L1
10
11
8
5
L2

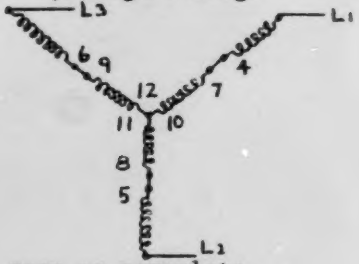
OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

As seen on nameplate

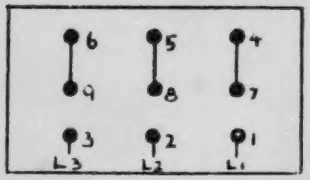

6
5
4
9
8
7
3
2
1
L3
L2
L1

(b) Wye high voltage connections.

Wye high voltage

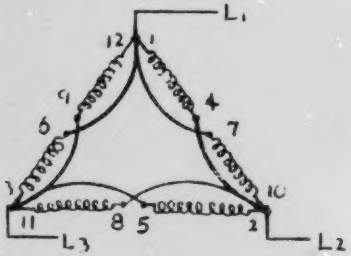

L3
L1
6
9
4
12
7
11
10
8
5
L2

As seen on nameplate


6
5
4
9
8
7
3
2
1
L3
L2
L1

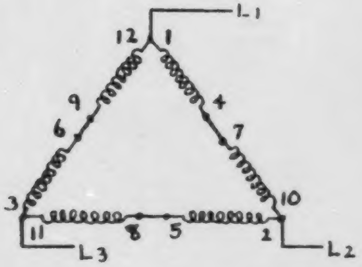
(c) Low-voltage delta connections.

Low voltage delta


L1
12
1
9
4
6
7
3
10
11
8
5
2
L3
L2

II.C.1.b.(2)(c) Complete connections on information sheet, CE "A" IS 1.3.11.2, "Three-Phase Motors".

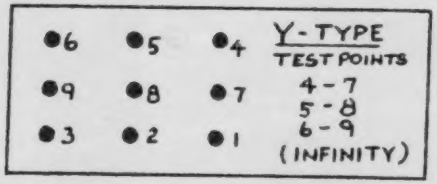
(d) High voltage delta connections.


L1
12
1
9
6
4
7
3
10
11
8
5
2
L3
L2

3. Testing for wye or delta.

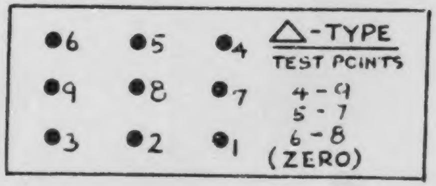
a. Ohmmeter - R x 100 scale.

a.


6
5
4
Y-TYPE
TEST POINTS
9
8
7
4-7
5-8
6-9
3
2
1
(INFINITY)

b. Both type motors - 9 leads are brought out.

b.


6
5
4
△-TYPE
TEST POINTS
9
8
7
4-9
5-7
6-8
3
2
1
(ZERO)

c. Uses.

(1) Machine lathes.

(2) Elevators.

(3) Hoists.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
D. Motor control systems.		
1. Motor branch circuit protection.	II.D.1. Display training aid of conductor protectoin portion of motor branch circuit.	
a. Fuse or circuit breaker - to protect conductors for grounds and shorts.		
b. Disconnect must be horsepower rated.		
(1) A general service fused disconnect is not designed for possible locked rotor currents.		
(2) Shall be in sight from controller.		
c. Film: TF-6180, "Motor Control Systems".	II.D.1.c. Discuss highlights of film.	II.D.1.c. Participate in discussion.
2. Motor controller.	II.D.2. Display training aid of motor controllers.	II.D.2. Complete connections on information sheet CE "A" IS 1.3.11.3, "Motor Control".
a. Definition: A device that operates and opens the circuit due to excessive motor overload.		
b. Components.		
(1) Operating coil.		
(2) Main contacts.		
(3) Auxiliary contacts.		
(4) Thermal coils.	II.D.2.b.(4) Explain where and why 3 thermal overloads are required.	
(5) Holding coil contact.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Operation.		
(1) Operation sequence.	II.D.2.c.(1) Follow training diagram depicting both motor and control circuits.	
3. Push-button control stations.	NOTE: Provide each student with the Allen-Bradley Manual for full-voltage starting switches.	
a. Stop-start.		
b. Start-jog-stop.		
c. Hand-off-auto.		
d. Forward-reverse-stop.		
e. Fast-slow-stop.		
4. Film: TF-5660, "Motor Controllers in Three-Phase and Single-Phase Induction Motors".	II.D.4. Show film and discuss practical application in Topic 1.3.12.	II.D.4. Participate in discussion.
III. Application.		
A. Practical performance.		
1. The student will perform the installation of a motor, motor controller and push button station during topic 1.3.12, in accordance with job sheet CE "A" JS 1.3.12.1, "Cubicle Wiring".		
IV. Summary.		
A. Single-Phase Motors.		
B. Single-Phase Induction Motors.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

C. Three-Phase Motors.

D. Motor Control Systems.

E. Job sheet.

F. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Cubicle Wiring

Average Time: 1 Period (Class), 26 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 7.
2. National Electrical Code, Article 300.

B. References: None.

C. Tools, Equipment and Materials:

1. Electrician's tool kit.
2. Hand and ratchet bender.
3. Motor.
4. Motor controller.
5. Push button stop-start button.
6. Circuit breaker panel.
7. Lighting fixtures.
8. Boxes.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to use electrician's tools and install boxes, fittings, motor, motor controller, push-button station, circuit breaker panel, rigid steel conduit, electrical metallic tubing, flexible metallic conduit, insulated conductors and non-metallic sheathed cable. Installation will be within the open-framed building in accordance with the job sheet CE "A" JS 1.3.12.1, "Cubicle Wiring", and will be 100% correct.

Criterion Test: The student will wire an open-framed building using electrician's tools and electrical construction material. Installation will be 100% correct.

Homework: None.

9. Fittings.
10. Electrical devices.
11. Rigid and flexible conduit.
12. Electrical metallic tubing.
13. Non-metallic sheathed cable.
14. #12 AWG insulated copper conductor.

D. Training Aids and Devices:

1. Locally prepared materials.
   a. Job Sheet.
      (1) CE "A" JS 1.3.12.1, "Cubicle Wiring".
   b. Drawings.
      (1) CE "A" DWG 1.3.12.1, "Cubicle Wiring Series Rooms #1 thru #6.

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Cubicle Wiring.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1 Introduce job sheet.	1. State information and materials necessary to guide student.	
2. Practical performance.		
3. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet.		
1. CE "A" JS 1.3.12.1, "Cubicle Wiring".		
B. Steps of procedure.	II.B. Assign cubicle to student teams and issue appropriate print from CE "A" DWG 1.3.12.1, "Cubicle Wiring Series 1 - 6.	
1. Make a list of materials required to install circuits #1 - #4.		
a. Count the number and type of boxes for the lighting, receptacle and motor circuits.	1. Indicate on chalkboard the required heights from floor level:	
b. Estimate the amount of conduit, single conductor wire and non-metallic sheathed cable.	a. Receptacles: 12" to center of box.	
c. Determine the fittings required to connect the conduit and cable to their appropriate junction boxes.	b. Switches: 48" to center of box. c. Motor controllers: 5' 6" to center.	
d. Estimate the amount of wood screws, staples and other hardware necessary to secure the wiring.		
e. List all switches, outlets, lighting fixtures, plates and the motor with associated control equipment.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
F. Submit the list of material to the material issue room and ensure that all boxes, fittings and hardware are complete after receipt of issue		
NOTE: Check out a complete set of electrician's tools and sign the custody card.		
2. Install outlet and junction boxes for circuits # 1 - #4.		
a. Circuit #1 - Using wood screws, install the two 2¼" and 2" gem boxes in the locations outlined on the print.	II.B.2.a. Boxes shall be mounted for ½" wallboard finish. All receptacles shall be 12" to center above finished floor.	
b. Circuit #2 - Using wood screws, install the three 2¼" x 2" gem boxes in the locations outlind on the print.		
c. Circuit #3 - Using ½" roofing shingle nails, secure the 4/S x 2 1/8" deep box and hanger assembly to be used for the flourescent fixture installation. Location shall be in accordance with the print.	II.B.2.c. Position the bar hanger to allow for ½" wallboard finish.	
Where print indicates "S_3" (3-way switches), mount a 2¼" x 2" gen box at each location.	NOTE: Switch boxes shall be mounted 48" to center above finished floor.	
Where print indicates "S_4" (4-way switch), mount a 4/S x ½" deep box with a single-gang plaster ring.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Circuit #4 - Using wood screws, mount the motor controller as per location indicated on the print.	II.B.2.d. Motor controller shall be mounted 5' 6" to center above finished floor.	
Install stop-start station below the motor controller with a 1/2" off-set nipple.		
Install a 4/11 x 1 1/2" deep junction box approximately 2 feet from the motor, in-line with the run to the controller.	NOTE: The run from the controller to the 4/11 box shall be in 1/2" E.M.T. From box to motor shall be in 1/2" flexible conduit.	
3. Install in circuits #1 and #2, non-metallic-sheathed cable, type NMC, 2-conductor #12 copper with ground as indicated.		
a. From panel to first outlet: At panel, skin the cable back approximately 12", install cable connector, insert conductors into panel knockout and secure connector with locknut.	II.B.3.a. Use extreme care when using cable skinning tool, "Do not damage insulation on conductors".	
b. Route the cable to the first outlet following the shortest practical route.	II.B.3.b. Keep cable free of kinks.	
c. Skin cable end approximately 6" and install cable connector on cable. Secure connector to junction box with locknut.		
d. Secure cable to studs with 2 staples, one at each end approximately 12 inches from box and panel.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Install cable to remaining outlets on circuits #1 and #2. Using procedures outlined in 3a - 3d as outlined above.		
4. Install 1/2" flexible metallic conduit from S_4 to flourescent light junction box. (Circuit #3, switch leg #3.)		
a. Select correct length of flexible conduit and install one end at the lighting outlet using a flexible conduit connector and locknut.		
b. Route the conduit as outlined on the print. Secure conduit to S_4 switch box as per 4a.		
c. Secure conduit to studs using conduit straps - one within 12 inches of switch box and one in close proximity to the lighting outlet.	II.B.4.c. Secure conduit straps with 1/2" shingle nails.	
5. Install 1/2" flexible metallic conduit from motor to junction box (circuit #4).		
a. Select length of flexible conduit (approximately 2 feet long) and install one end at the motor terminal box.		
b. Secure other end to 4/11 x 1 1/2" deep junction box.	II.B.5.b. Do not secure this length of conduit with a strap. Flexibility required for motor vibration.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
6. Install 1/2" electrical metallic tubing from S_3 to flourescent light junction box. (Circuit #3, Switch leg #2).	II.B.6. The conduit run shall be run concealed in the attic space and the wall partition.	
a. Use the 6' folding rule to measure the distance from the flourescent light junction box to S_3. (Switch leg #2.)		
b. Select one or two lengths of 1/2" E.M.T. as required.		
c. First step - Form a 6" stub-up on one end of conduit following the measuring and bending procedures outlined in the attached drawing titled "Accurate Stubs".	II.B.6.c. Inform students to locate a small piece of 1/2" E.M.T. and practice with their assigned hand bender.	II.B.6.c. Practice bends as shown on applicable pages of job sheet.
d. Second step - Form a back-to-back bend with the first 90° bend (6" stub-up) following the measuring and bending procedures outlined in the attached drawing titled "Back-to-Back Bends".	II.B.6.d. Take-up measurement varies between different benders.	
e. Install conduit with short stub and E.M.T. connector to the lighting outlet box. Long stub will enter hole in top plate above S_3..		
f. In the second piece of conduit, bend an offset near one end. Amount of offset will depend upon location of knockout in S_3 gem box.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
g. Measure distance between top of switch box and end of conduit, subtract 1/8", cut and ream, and secure conduit ends together with a coupling. Secure conduit run to switch box with a connector and locknut.	II.B.6.g. Ensure that all fittings and locknuts are tight.	
7. Install non-metallic-sheathed cable, type NMC, 3-conductor, #12 copper with groung. (Circuit #3, switch leg #1.)	II.B.7. Students will select the piece of 3 conductor cable that would be close to the measurement from S_3 to lighting outlet.	
a. Use same procedures as outlined for circuits #1 and #2.		
8. Install ½" electrical metallic tubing for home run (Circuit #3).		
a. Use same procedures as outlined for item #6. (Circuit #3, switch leg #2). Start run from lighting outlet.		
9. Install type T.W. conductors between panel and lighting outlet. (Circuit #3, home run).		
a. Insert fish tape into circuit #3's E.M.T. home run at the panel. Push until 12" of end is exposed at lighting outlet box.		
b. Skin the ends of 1 white and 1 black type TW, #12 conductors approximately 3". Bend the exposed copper at the insulation and install on the fish tape. Apply 3 or 4 wraps of electrical tape up and down the connection.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Pull fish tape at the panel until approximately 12" of wire is exposed.	II.B.9.c. While one man is pulling on the fish tape, an assistant will apply pressure on the conductors at the junction box.	
d. Leave approximately 6" of free length (at junction box) when cutting the conductors from the rolls.		II.B.9.d. Remove tape on fish tape and prepare for item #10.
10. Install type TW conductors between S_4 and lighting outlet. (Circuit #3, switch leg #3.)		
a. Select 2 coils of red and 2 coils of blue type TW #12 single conductor wire.		
b. Insert fish tape into flexible conduit at the lighting outlet and push until 12" of end is exposed at S_4 switch box.		
c. Follow procedures in item #9 for securing conductors to fish tape and pulling in conduit.	II.B.10.c. Remove tape on fish tape and prepare for item #11.	
11. Install type TW conductors between S_3 and lighting outlet (Circuit #3, switch leg #2).		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Select 1 coil of black, 1 coil of red and 1 coil of blue, type TW #12 single conductor wire.		
b. Insert fish tape into E.M.T. at the lighting outlet and push until 12" of end is exposed at S_3 switch box.		
c. Follow procedures in item #9 for securing conductors to fish tape and pulling in conduit.	II.B.11.c. Remove tape and ensure that 6" of free length of conductor is in the box.	
12. Install 1/2" electrical metallic tubing from motor controller to junction box. (Circuit #4.)		
a. Select one or two lengths of 1/2" E.M.T. as required.		
b. Conduit shall be run "surface mount" from top of controller to concealed run in the attic.		
c. Starting at controller, measure for offset and bend as required in one end of conduit.		
d. Measure distance from top of controller to top of ceiling joist. Lay out measurements according to attached drawing "Accurate Stubs"		
e. Make 90° bend and place offset end with connector into controller knockout.	II.B.12.e. Do not install locknut at this time.	

OUTLINE OF INSTRUCITON | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

f. Position conduit and mark with pencil 1/8" from edge of junction box at the knouckout.

g. Cut, ream, and install connector.

h. Secure both ends with locknuts, and strap conduit above controller using 1/2" E.M.T. strap and 1/2" shingle nails.

13. Install 1/2" electrical metallic tubing from panel to junction box. (Circuit #4 - home run).

a. Conduit shall be run concealed in stud area above the panel.

b. Use available short pieces of 1/2" E.M.T. for the 90° stud bend from panel and offset to junction box.

14. Install type TW conductors between panel to motor junction box, and from junction box to controller.

a. Insert fish tape into E.M.T. at junction box and push until 12" of end is exposed at the panel.

b. Skin the ends of 2 black and 1 white type TW, #12 conductors. Follow installation procedures outlined in item #9.

II.B.14.b. Remove tape on fish tape and prepare for item #14c.

c. Insert fish tape into E.M.T. at junction box and push until 12" of end is exposed at the controller.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Skin the ends of 3 black and 1 white type TW, #12 conductors and repeat item #9 procedures.		
15. Install type TW conductors between controller and push-button station (circuit #4).		
a. Install 1 white, 1 black and 1 red type TW, # 12 conductors. Determine length by estimating distance by routing each conductor from terminal to terminal. Cut, skin and secure each in accordance with attached drawing titled "Single Phase Motor Controller Connections".		
16. Connect circuit conductors at motor controller and motor (Circuit #4).		
a. Follow the attached diagram titled "10 Motor Controller Connections" for controller and motor connections.	II.B.16.a. Ensure that all connections at controller are made in a clockwise direction.	
17. Connect all switches and make necessary splices (Circuit #3).		
a. Follow the attached diagram titled "3 and 4 Way Circuit Diagram for Circuit #3".	II.B.17.a. Conduct rough wiring inspection for evaluation. Installation shall be 100% correct.	
18. Complete installation with switch and receptacle plates, covers and fixture assembly.		
a. Follow examples outlined on display board.		

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19. Test all circuits.'

    a. Energize panel: Place main disconnect in ON position.

    b. Circuits #1 and #2: Turn ON circuits #1 and #2 breakers and test each outlet for presence of 115 volts between parallel slots and small slot to ground. Should read 115 volts.

    c. Circuit #3: Turn ON circuit #3 breaker and test each light switch for proper operation.

    d. Circuit #4: Turn ON circuit #4 breaker and test motor circuit for on-off operation via push-button.

NOTE: All circuits shall operate 100% correct.

III. Application.

A. Practical performance.

1. The student will install circuits #1 - #4, using electricians tools and electrical construction material. Installation and evaluation will be done in accordance with Job Sheet CE "A" JS 1.3.12.1, "Cubicle Wiring".

IV. Summary.

A. Introduce job sheet.

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

B. Steps of procedure.

C. Practical performance.

D. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Maintenance and Troubleshooting

Average Time: 2 Periods (Class), 7 Periods (Pract)

Instructional Materials:

A. Texts: None.

B. References:

   1. NAVFAC MO-116, Facilities Engineering Electrical Facilities, March 1972.

C. Tools, Equipment and Materials:

   1. Electrician's tool kit.
   2. Step ladder, 6 foot.
   3. Completed cubicle wiring: circuits #1 - #4.
   4. Voltage tester (Wiggins).
   5. Wiping rags.

D. Training Aids and Devices:

   1. Locally Prepared Material:

      a. Job sheet.

         (1) CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting".

E. Training Aids Equipment; None.

Terminal Objective: Upon completion of this unit the student will be able to use electrician's tools to install and test electrical material and equipment within an open-framed building, and a reinforced concrete slab area with surrounding concrete masonry unit wall. Installations will conform to the completed drawings that follow prescribed code rulings and calculations as outlined in the appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to perform maintenance and troubleshooting procedures on interior wiring circuits, motor controllers, motors and associated equipment. Steps of procedure will be in accordance with job sheet CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting" and will be 100% correct.

Criterion Test: The student will demonstrate his ability by performing maintenance and troubleshooting on interior wiring circuits, motor controllers, motors and associated equipment as outlined in job sheet CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting". Procedures will be executed 100% correct.

Homework: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Maintenance and Troubleshooting.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Job sheet.	1. State information and materials necessary to guide student.	
2. Steps of procedure.		
a. Maintain and test circuit breaker panel.		
b. Inspect conduit and cable systems.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Maintain and test flourescent circuit.		
d. Maintain and test motor, motor controller and push button station.		
3. Questions.		
II. Presentation.		
A. Introduce job sheet.		
1. CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting".		
B. Steps of procedure.		
1. Maintain and test circuit breaker panel.		
a. Ensure that the main breaker is in the OFF position.		
b. Label all circuits with circuit number and type.		
c. Check interior of panel for cleanliness.		
d. With a screwdriver, check all circuit breaker load connections. DO NOT OVER TIGHTEN.		
e. Check load balance (equal distribution of load across the two phases).	II.B.1.e. Calculate approximate load using the following factors, on chalkboard: 1. Receptacle - 180 watts.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	II.B.1.e. (Cont'd) 2. Flourescent Fixture - 100 watts. 3. 1 H.P. Motor - 746 watts a. Provide an example using the above factors.	
f. Grounding - check connections at panel and ground rod.	II.B.1.f. Circuit breaker panel and grounding system maintenance and load balance steps of procedure shall be performed 100% correct.	
2. Inspect conduit and cable systems.		
a. Electrical metallic tubing: Check all connectors and couplings by hand. If loose, tighten with adjustable open-end wrench.		
(1) Check securing of E.M.T. for proper number of bends, type of straps and their location.		
b. Flexible metallic conduit: Check all conduit connectors by hand. Remove any sharp edges at terminations of conduit.		
(1) Check securing of flex conduit for proper number of bends, type of straps and their location.	II.B.2.b.(1) Total number of bends shall not exceed 360°.	

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Non-metallic-sheathed cable: Ensure that all cable runs are within the concealed areas of the building.		
(1) Check all cable connectors at the panel and junction boxes. DO NOT OVERTIGHTEN SCREWS ON CABLE CONNECTORS.	II.B.2.c.(1) Damage to cable insulation will occur when cable connector is secured too tight.	
(2) Ensure that the location, and proper number of staples were installed to secure the cable. "Check for staples hammered too tightly on the cable."	II.B.2.c.(2) Damage to cable insulation will occur when staples are hammered beyond the safe limit. Inspection of conduit and cable wiring systems shall be performed 100% correct.	
3. Maintain and test flourescent circuit.		
a. Check fixture reflector for cleanliness. Clean if required.		
b. Check flourescent lamps for seating firmly and correctly in the lamp holders.		
c. Turn ON lighting circuit breaker at panel.		
d. Test 3 way and 4 way switches for proper operation.	II.B.3.d. If switches do not operate correctly, review the drawing titled "3 and 4 Way Circuit Diagram" for circuit #3.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Turn light ON: If lamp flickers, swirls or flutters, turn OFF for a few minutes - then turn ON. Change lamps if flicker remains.	II.B.3.e. If flickering lamp is not replaced, it may cause damage to the ballast.	
4. Maintain and test motor, motor controller and push button station.		
a. Ensure that the motor circuit disconnect (at the panel) is in the OFF position.		
b. Motor controller: Remove cover and check for dirt, pieces of copper wire, presence of moisture and loose connections.	II.B.4.b. Clean out all loose particles and tighten any loose connections. DO NOT OVERTIGHTEN.	
(1) Check the ampere rating of the thermal overload units and compare with the name-plate ampere rating on the motor.	II.B.b.(1) If the current ratings differ by 4 or more amps, report this to the instructor.	
(2) Check contacts for making full contact. Push contact assembly with finger positioned below solenoid (coil).	II.B.4.b.(2) This check will also ensure free travel of contact assembly.	
(3) Cleaning contacts: Use extra fine sandpaper and remove high spots on contacts, if required. DO NOT USE EMERY CLOTH!!		
c. Push-button station: Remove cover and check for loose connections and conductors interfering with travel of moving parts.	II.B.4.c. Operate Stop and Start buttons to ensure free travel of moving parts.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Replace covers on controller and push-button station. Place circuit #4 (disconnect at panel) to the ON position.	II.B.4.d. Maintenance and testing procedures shall be performed 100% correct.	
(1) Pust Start button and check motor for proper operation.		
e. Motor does not operate:		
(1) Turn circuit disconnect to OFF position.		
(2) Use a step ladder to get in position to check the splices and motor connections in the attic area.		
(3) Refer to the wiring diagram "Single Phase Motor Controller Connections" and make corrections as required.		
(4) Repeat starting procedures and check system for proper operation.	II.B.4.e.(4) Maintainence and testing procedures shall be performed 100% correct.	
III. Practical application.		
A. Maintenance and testing procedures will be done in accordance with job sheet CE "A" JS 1.3.13.1, "Maintenance and Troubleshooting".		
IV. Summary.		
A. Job sheet.		
B. Steps of procedure.		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
C. Practical application.		
D. Questions.		
V. Test: None.		

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CONSTRUCTION ELECTRICIAN SCHOOL

CLASS "A"

INSTRUCTOR GUIDES

PHASE 2

3-16

Power Generation & Distribution

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Tying Knots

Average Time: 2 Periods (Class), 4 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Material:

1. Classroom training poles.
2. Practice pole climbing areas.
3. Handlines (complete with 4 ft. attaching lines).
4. 12 foot lengths of 1/2" synthetic lines (one per student).
5. Crossarms.

D. Training Aids and Devices:

1. Locally prepared material:

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system up to 5000 volts and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to tie a timber-hitch, half-hitch, clove-hitch, bow-line, grunt's knot and properly make up a handline for stowage. Knots will be tied in a 6 foot length of 1/2" line in accordance with the procedures outlined in Job Sheet CE "A" JS 2.1.1.1, "Tying Knots". Knot tying procedures will be executed without error.

Criterion Test: The student will tie a timber-hitch, half-hitch, clove-hitch, bow-line, grunt's knot and properly make up a handline for stowage. Knots will be 100% correct.

Homework: Read:

1. Lineman's and Cableman's Handbook:
   a. Section 4, pp. 4-1 thru 4-12.
   b. Section 10, pp. 10-1 thru 10-17.
   c. Section 45, pp. 45-1 thru 45-4 and pp. 45-26 thru 45-30

a. Knot tying display board.

b. Job sheet.

(1) CE "A" JS 2.1.1.1, "Tying Knots".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Tying Knots.		
B. Establish readiness:	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better construction electrician.		
D. Overview:	I.D. State learning objectives.	
1. Job Sheet.	1. State information and materials necessary to guide student.	
2. Knot-tying demonstration.		
3. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet.		
1. CE "A" JS 2.1.1.1, "Tying Knots".	II.A.1. Hand out CE "A" JS 2.1.1.1, "Tying Knots".	
B. Steps of procedure.		
1. Prepare handline for use.	II.B.1. Uncoil handline for students.	
a. Uncoil handline.		
2. Prepare handline for storage.	II.B.2. Make up handline for storage.	
a. Two-block snap and ring with shive block.		
b. Coil in clockwise direction into 2 1/2' - 3' coil.		
c. Use tail of handline to keep made up.		
3. Secure handline to top of pole with 4 foot attaching line.	II.B.3. Demonstrate tying timber hitch on training pole.	
a. Using timber hitch.		
(1) Bitter end of 4 foot tail around the pole (6" from top), and lay on top of secured end. Bring under secured end and spiral back upon itself approximately 4 times. While holding bitter end, apply pull on secured end and draw tight.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Tie a clove-hitch and a half-hitch on a crossarm.		
a. Lay crossarm in a horizontal position on the ground with one end resting on top of line boot.	II.B.4.a. Demonstrate placing crossarm on line boot.	
b. Apply clove hitch to elevated end of crossarm by making two overhand loops (close to the snap and ring assembly), pass second loop behind first, then install over end of crossarm. Tighten by pulling firmly on both ends.	II.B.4.b. Demonstrate proper way to tie a clove-hitch on the arm.	II.B.4.b. Observe demonstration.
c. Rest opposite end of crossarm on line boot and apply a half-hitch by moving slack from line, (between clove-hitch and half-hitch). Make one overhand loop formed and placed over end of crossarm so that tension on running end will tighten loop around crossarm.	II.B.4.c. Demonstrate proper way to tie half-hitch on other end of arm.	II.B.4.c. Observe demonstration.
5. Tie a clove-hitch and finger line on a crossarm.		
a. Tie a clove-hitch same as before.	II.B.5.a. Tie clove hitch.	
b. Extend running end of handline up alone arm.	II.B.5.b. Demonstrate running handline along arm.	
c. Secure handline to top of arm.	II.B.5.c. Demonstrate securing handline to top of arm.	
(1) Pass a 3/8" finger line through the tip pin hole of arm.		
(2) Secure around arm and handline with a bow knot.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
6. Grunt's knot. a. Used to raise tools and materials. b. Can be untied from the ground.	II.B.6. Demonstrate tying a grunt's knot.	
7. Bowline. a. Places a loop in the end of a line. b. Will not slip or pull tight.	II.B.7. Demonstrate tying a bowline, following procedures outlined in the Lineman's and Cableman's Handbook, pp. 41-6.	
III. Application. A. Students practice preparing a handline for use and storage. B, Students practice tying knots. C, Students practice raising crossarms as outlined by instructor.	III. Issue students climbing gear, handlines and a 12' length of 1/2" diameter line.	
IV. Summary. A. Steps of procedure. 1. Prepare handline for use. 2. Prepare handline for storage. 3. Secure handline to pole. 4. Tie a clove-hitch and half-hitch on a crossarm. 5. Tie a clove hitch and fingerline on a crossarm.		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
6. Tie a grunt's knot.		
7. Tie a bowline.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Framing Poles

Average Time: 1 Period (Class), 5 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Materials:

1. 6 foot folding rule.
2. Framing square (24" x 36").
3. Cant Hooks.
4. Utility saw.
5. Lineman's hammer.
6. Chisel (2" wood).

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to frame a power pole in accordance with Job Sheet CE "A" JS 2.1.2.1, "Framing Poles". Framing tolerances will be 100% correct.

Criterion Test: The student will frame a power pole within the tolerances outlined in the Job Sheet CE "A" JS 2.1.2.1, "Framing Poles".

Homework: Read:

1. Lineman's and Cableman's Handbook:
    a. Section 11, pp. 11-1 thru 11-26.
    b. Section 45, pp. 45-5 thru 45-7.

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7. Wood brace.

8. Auger bit 11/16" x 14".

9. Chalkline.

10. Tape measure, 100 ft.

11. 5 foot sections of power poles.

D. Training Aids and Devices:

1. Films.

   a. MA-2564, Installation of Crossarms, (18 min.).

2. Locally Prepared Material:

   a. Framed pole display.

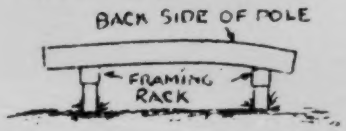
   b. Job Sheet.

      (1) CE "A" JS 2.1.2.1, "Framing Poles".

E. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Framing Poles.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.	1. Define framing.	
2. Assignment.	2. Framed according to intended usage.	
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better construction electrician.		
D. Overview:	I.D. State learning objectives.	
1. Job Sheet.	1. State information and materials necessary to guide student.	
2. Terms and definitions.		
3. Framing demonstration.		
4. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet and film.		
1. CE "A" JS 2.1.2.1, "Framing Poles".		
2. MA-2564 "Installation of Crossarms".	II.A.2. Show film and discuss highlights.	II.A.2. View film and participate in guided discussion.
B. Roofing the pole:		
1. Prevents water, snow or ice from collecting on top and causing decay.		
2. Steps of procedure.	II.B.2. Draw sketch on chalkboard: 	
a. Position pole on two (2) crossarms or short sections of poles, face up.		
b. Rotate pole 90°.	II.B.2.b. Show; cant hooks used to turn and hold poles for framing.	II.B.2.b. View cant hooks
c. On back side - measure from top down 1" and mark with chalk or pencil. Complete angle of 15° by drawing line from top of face to mark on back side of pole.		
d. Using a crosscut saw, follow chalk/pencil line and cut roof.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

C. Cutting a single gain:

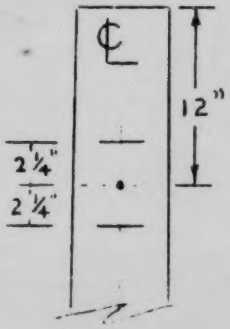
1. Locate pole on two (2) crossarms or sections of poles, face up.

2. Snap a ℄ face of pole from roof to butt.

NOTE: ℄ Denotes centerline.

3. On ℄ measure down 12" from peak of roof and mark, this is the center of the gain.

3. Sketch on chalkboard.



4. On the ℄ measure 2 1/4" mark, and mark, this denotes the top and bottom limits of the gain.

5. Using the crosscut saw, cut 1/2" deep at top and bottom marks of the gain.

   a. Make cut 90° with axis of pole.

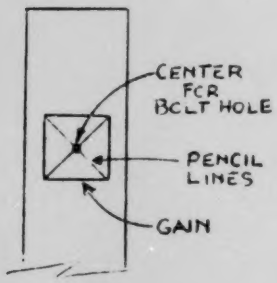
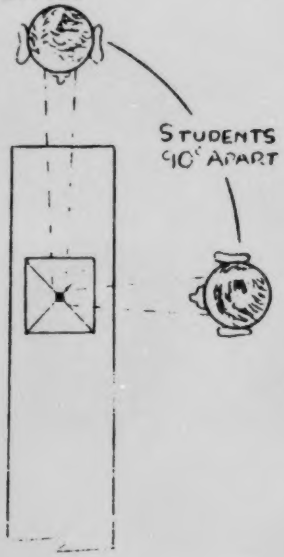
6. Using the lineman's hammer and a 2" wide wood chisel.

   a. Split the gain on ℄ into two equal halves.

   b. From outside to center of gain, drive chisel and remove 1/2 of gain at a time.

   c. **Finished gain should be slightly concave.**

II.B.6.c. Keeps crossarm from rocking motion.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
7. Crossarm through bolt hole.		
a. Draw two diagonal pencil lines that intersect in the center of gain.	II.B.7.a. Sketch on chalkboard:  	
b. Use wood brace and 11/16" auger-bit. More hole at the center of each gain.	II.B.7.b. Demonstrate how to maintain vertical boring position with two students 90° apart sighting for accuracy.	II.B.7.b. 
D. Cutting multiple gains on face of pole.		
1. Snap ℄ on face of pole from roof to butt.		
2. Measure from roof down 12 1/2" on ℄, this is center of first gain.		

3. Second gain.

   a. Measure down 24" from center of first gain, and mark center of second gain.

4. Third gain.

   a. Measure down on ℄ 24" from center of second gain, and mark center of third gain.

5. Mark upper and lower limits of gains as before.

   a. 2 1/4" above and below center.

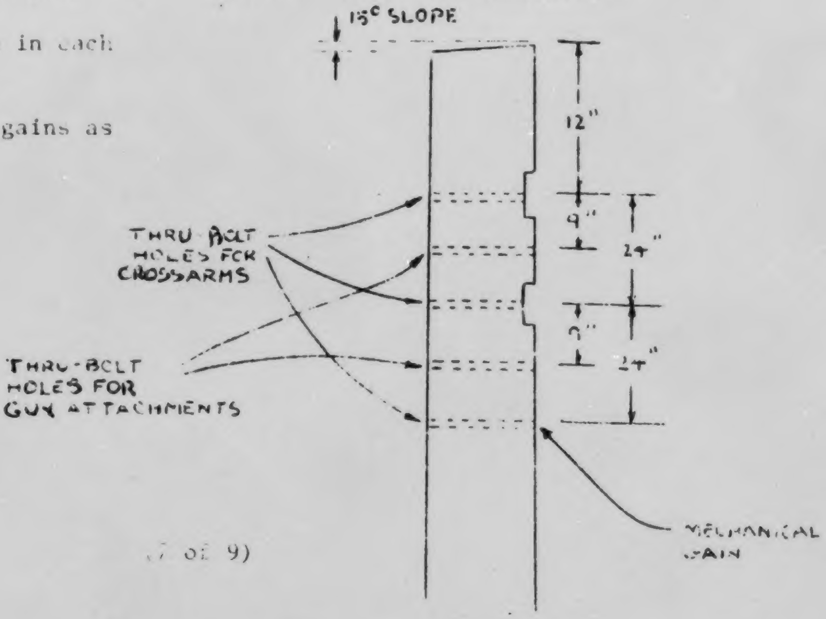
6. Remove wood from gains as before.

7. Check gains for parallel surfaces.

   a. Two framing squares, one in each gain.

   b. Sight squares and level gains as needed.

II.D.7. Sketch on chalkboard.


15° SLOPE
12"
9"
24"
9"
24"
THRU BOLT HOLES FOR CROSSARMS
THRU-BOLT HOLES FOR GUY ATTACHMENTS
MECHANICAL GAIN

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

E. Cutting gains for buck arms.

1. Measure down ℄ from center of line arm 24" and mark.

2. Measure circumference of pole at buck arm mark.

3. Divide circumference by (4).

   a. 24 ÷ 4 = 6.

4. From mark on center line measure the distance obtained above.

   a. 6".

5. Rotate pole 90° so that new mark is on top.

   a. Use cant hooks.

6. Place bolt in line arm through bolt hole to help align the 90° relationship.

7. Measure and cut gain as before.

8. Drill buck-arm through bolt hole as before, using bolt in line arm to keep the required 90° alignment.

9. Check finished gains for accuracy with two (2) framing squares.

   a. One in each gain.

   b. Sight as before.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
F. Mechanical gain.	II.F. Show mechanical gain.	
1. No cutting required.		
2. Drill hole for crossarm bolt.		
G. Guy attachment holes.		
1. In line with line or buck arm.		
2. 9" below same.		
III. Application.		
A. Student practice - framing a pole.		
IV. Summary.		
A. Cutting the roof.		
B. Cutting a single gain.		
C. Cutting multiple gains on same surface.		
D. Cutting gains for buck arms.		
F. Mechanical gains.		
F. Guy attachment holes.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0016

Classification: Unclassified

Topic: Erecting and Setting Poles

Average Time: 2 Periods (Class), 7 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz, McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Material:

1. Tools:
   - a. Digging bar.
   - b. "D" handled shovel.
   - c. Straight shovel.
   - d. Spoon shovel.
   - e. Tamping bar.
   - f. Pike poles.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will have witnessed the installation of a framed power pole using an earth auger and line truck, and will be able to perform as a crew member the piking method of raising and setting a 35 foot power pole. Practical performance will be done without error in accordance with the Job Sheet CE "A" JS 2.1.3.1, Erecting and Setting Power Poles".

Criterion Test: The student will be evaluated upon his assigned task as a crew member in erecting and setting a pole. All work will be 100% correct.

Homework: Read:

1. Lineman's and Cableman's Handbook:
   - a. Section 4, pp. 4-12 thru 4-20.
   - b. Section 4, pp. 4-24 thru 4-30.
   - c. Section 13, pp. 13-1 thru 13-10.
   - d. Section 45, pp. 45-10 thru 45-13.

g. Cant hooks.

h. Carrying hooks.

i. Sighting rod.

2. Equipment:

a. Line truck.

b. Earth auger.

3. Materials:

a. 35 foot pole.

b. Butt board, 2" x 12" x 8'.

D. Training Aids and Devices:

1. Films:

a. MA-5741-A2, "Erecting Large Poles" (21 min.).

2. Locally Prepared Materials.

a. Job sheet.

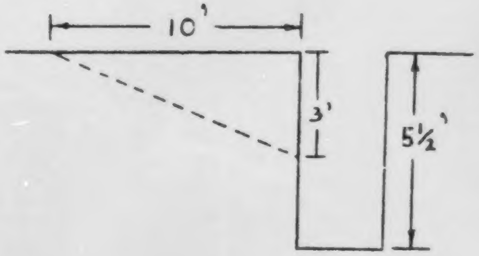
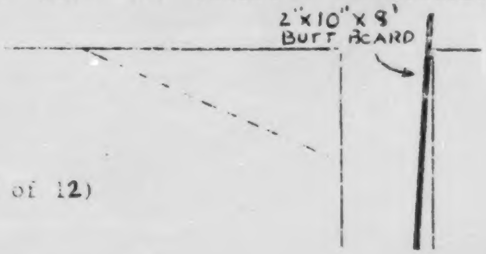
(1) CE "A" JS 2.1.3.1, "Erecting and Setting Power Poles".

E. Training Aids Equipment:

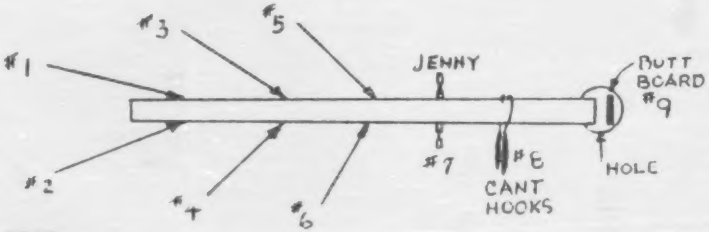
1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Erecting and Setting Poles.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Job sheet.	1. State information and materials necessary to guide student.	
2. Terms and definitions.		
3. Steps of procedure.		
4. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet and film.	II.A. Pass out CE "A" JS 2.1.3.1, "Erecting and Setting Poles"	
1. CE "A" JS 2.1.3.1, "Erecting and Setting Poles".	II.A.1. Define the terms used in setting a pole.	
2. MA-5741-A2, "Erecting Large Poles".	II.A.2. Show film.	II.A.2. View film.
3. Steps of procedure.		
1. Pole hole.		
a. Depth - calculation shall be in accordance with length of pole and type of soil.	II.B.1.a. Show example on chalkboard: 40 foot pole in normal soil: 10% of the pole length and add 2 feet. Minimum depth 5 feet. 10% of 40 - 4 feet + 2 feet = 6 feet required for depth of hole.	
(1) In rocky soil - in accordance with the recommendations outlined in the Lineman's and Cableman's Handbook, page 11-2.	II.B.1.a.(1) Review information in Lineman's and Cableman's Handbook.	
(2) In sandy or swampy soil - in accordance with the procedures outlined in the Lineman's and Cableman's Handbook, page 11-3.	II.B.1.a.(2) Review information in Lineman's and Cableman's Handbook.	
b. Diameter - 6" greater than the diameter of the pole at the butt.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Digging trench to pole hole.		
a. Trench is required to easily accomodate the width of the pole.	II.B.2.a. Sketch on chalkboard.  	II.B.2.a. Depth of hole will be within ± 6 inches. Diameter of hole will be within + 6 inches to + 9 inches of pole diameter.
b. Length and depth of trench will vary according to size of pole.		
3. Setting pole in hole.	II.B.3. Refer to Lineman's and Cableman's Handbook, pages 11-9 to 11-12 for piking method, and table outline of how the size of the piking crew depends upon the length and weight of the pole to be raised.	
a. Assign numbers 1 - 10 to piking crew and crew leader. (1) #1 - 6 "Pikers". (2) #7 "Jenny Operator". (3) #8 "Cant Hook Operator". (4) #9 "Butt-Board Man". (5) #10 "Crew Leader".		
b. #9 will position butt board in hole.	II.B.3.b. Sketch on chalkboard.  	II.B.3.b. #10 will ensure that board is properly positioned in the bottom of the hole.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. #10 will issue command to # 1 - 6 to place pole in trench with butt of pole against the butt-board.		
(1) #1 - 6 will use 3 carrying hooks to place pole in trench.		
d. #10 will issue command to #1 - 6 to raise end of pole by hand, and #7 to place "Jenny" under the pole for support.		II.B.3.d. All commands shall be stated 100% correct.
e. #10 will issue command to position pikes.	II.B.3.e. Sketch on chalkboard.	



f. Raise pole upon command until rear pikers #1 and #2 yell "High Pike". Stop raising pole and allow #7 to move forward with jenny under pole to new position.

g. With jenny repositioned, #5 and #6 will repike their poles (one at a time). The other men will follow in order until all the pikes are lowered. #10 issue command to raise pole until "High Pike" is yelled by rear pikers. Follow the piking procedures until pole settles in the hole.

(1) #8 will reposition cant hooks as pole decends further into the hole.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(2) #9 ensures that butt-board does not bind the pole by becoming cocked in the hole.

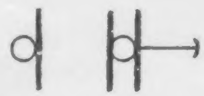
(3) #10 will align the pole by informing #8 to turn the pole so that it is properly faced.

(a) Dead-ends.

1. Dead-end poles face dead-end.

2. Adjacent poles also face dead-end.

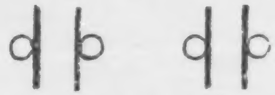
II.B.3.g.(3)(a) Sketch on chalkboard.



(b) Straight lines.

1. Back to back and gain to gain.

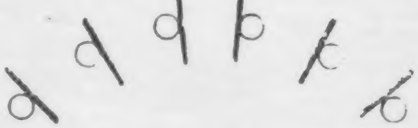
II.B.3.g.(3)(b) Sketch on chalkboard.



(c) Curved lines.

1. All poles face center of curve.

II.B.3.g.(3)(c) Sketch on chalkboard.

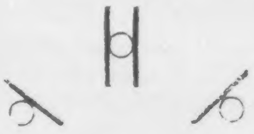


(d) Angle lines.

1. Angle pole bisects the angle.

2. Adjacent poles face angle.

II.B.3.g.(3)(d) Sketch on chalkboard.



OUTLINE OF INSTRUCTION

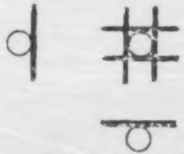
INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

(e) Corners.

1. Same as dead-end poles, because a 90° corner is really two dead-ends 90° displaced.

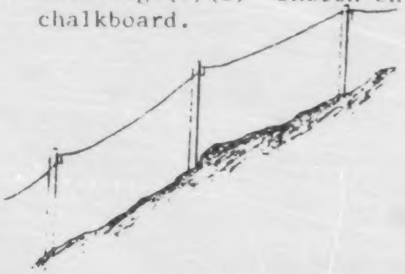
II.B.3.g.(3)(e) Sketch on chalkboard.



(f) Steep grades.

1. Face up hill.

II.B.3.g.(3)(f) Sketch on chalkboard.

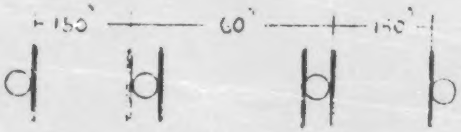


(g) Crossings.

1. Shorter than average span length.

   a. Adjacent poles face crossing.

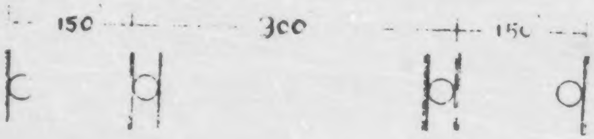
II.B.3.g.(3)(g) Sketch on chalkboard.

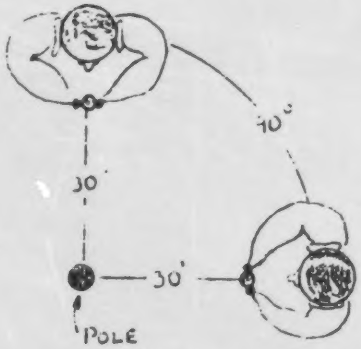


2. Longer than average span length.

   a. Adjacent poles face away from crossing.

II.B.3.g.(3)(g)2. Sketch on chalkboard.



OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(4) #9 and #10 will use a pike pole held vertically with the point in the ground, positioned approximately 30 feet from the pole so that alignment can be determined from 2 positions, 90° apart.	II.B.3.g.(4) Sketch on chalkboard.  	II.B.3.g.(4) 30' can be stepped off with 10 normal walking steps.
(5) #1 - #4 will set the bottom of their pike poles firmly on the ground 90° apart around the pole with pikes in the pole (all 4 at same level).		
4. Backfill and tamp dirt in hole around pole.	II.B.4. Ensure that ALL the dirt is firmly compacted back in the hole.	
a. #9 will shovel dirt into hole.	II.B.4.a. Vertical position of pole and gain direction will be 100% 100% correct.	
b. #5 and #6 will tamp.		
c. Pikers #1 - #4 will remove aligning pikes when 1/2 the hole is filled and tamped.		
5. Setting framed pole with earth auger and line truck.	II.B.5 Demonstrate: Operating Characteristics of the earth auger and line truck. Stress: all safety precautions.	II.B.5. Students will render assistance when required by the instructor.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Excavate hole with earth auger.	II.B.5.a. Demonstrate: Align pole location with other poles in pole line, and how to use the earth auger to excavate hole.	
(1) Determine exact location for pole hole.		
(2) Position auger above pole location and align boom with vertical and horizontal levels.		
(3) Excavate hole to a depth of 5 1/2 feet.		
b. Position pole at pole hole with line truck.	II.B.5.b. Demonstrate: Use of line truck in picking up and positioning pole at pole hole.	
(1) Determine approximate balance point slightly above mid-point of pole.		
(2) Attach winch cable around pole and raise approximately 3 to 4 feet.		
(3) Place pole alongside of the hole so that the balance point and the center of the hole are in line.		
c. Raise and set pole with the line truck "A" frame.		
(1) Operate winch lever to release winch cable.	II.B.5.c.(1) Demonstrate: Releasing winch cable.	II.B.5.c.(1) With tag line attached to the eye of the cable, maintain tension as cable is lowered.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Attach winch cable slightly above former balance point.		II.B.5.c.(2) Follow instructor's directions as to where and how to attach "J" hook and cable.
(3) Operate winch in the raise position.	II.B.5.c.(3) Demonstrate: Removing cable slack and raising the pole.	II.B.5.c.(3) Stand aside while pole is being raised.
(4) Position the pole over the hole.	II.B.5.c.(4) Demonstrate: Raise butt of pole to approximately 1 foot above the ground. Position butt of pole directly over the hole.	
(5) Lower the pole in the hole.	II.B.5.c.(5) Demonstrate: Lowering of pole by operating the winch control.	
(6) Align the pole and backfill.	II.B.5.c.(6) Position four students with pike poles at 90° intervals around the pole and align pole with one cant-hook operator.	
(7) Secure all equipment in the parking area.		
III. Application.		
1. Student practice erecting and setting poles.		
IV. Summary.		
1. Job Sheet.		

2. Steps of procedure.

   a. Pole hole.

   b. Digging trench to pole hole.

   c. Setting pole in hole.

   d. Backfill and tamp dirt in hole around pole.

V. Test: None.

CE "A" IG 2.1.4

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Mounting Crossarms, Pins and Insulators

Average Time: 2 Periods (Class), 13 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.

2. Lineman's and Cableman's Handbook, 4th edition, Kurtz, McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Materials:

1. Lineman's tool kit.

2. Climbing gear.

3. Handline.

4. Additional line material as listed in NAVFAC DWG 1109831.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to mount single and double crossarms, and install pins and insulators on the 35 foot poles in accordance with Job Sheet CE "A" JS 2.1.4.1, "Mounting Crossarms, Pins and Insulators". Steps of procedure must be 100% correct.

Criterion Test: The student will assemble and mount crossarms on a pole. Installations will be 100% correct.

Homework: Read:

1. Lineman's and Cableman's Handbook:
   a. Section 4, pp. 4-21 thru 4-23.
   b. Section 12, pp. 12-1 thru 12-31.
   c. Section 45, pp. 45-19 thru 45-21.

D. Training Aids and Devices:

1. Locally Prepared Material.

a. Crossarm and Hardware display.

b. Job Sheet.

(1) CE "A" JS 2.1.4.1, "Mounting Crossarms, Pins and Insulators".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Mounting Crossarms, Pins and Insulators.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Job Sheet.		
2. Materials required - Single arm.		
3. Steps of procedure - Single arm.		
4. Materials required - Double arm.		
5. Steps of procedure - Double arm.		
6. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet.		
1. CE "A" JS 2.1.4.1, "Mounting Crossarms, Pins and Insulators".		
B. Materials Required - Single arm installation.	II.B. Introduce crossarm, identify top and bottom of arm.	II.B. Observe materials as introduced in demonstrations.
1. Crossarm.		
a. One each.		
2. Mechanical gain.	II.B.2. Introduce mechanical gain.	
a. One each.		
3. Flat braces.	II.B.3. Introduce flat braces. Note two hole sizes, 7/16" and 9/16".	
a. Two each.		
b. 28".		
4. Brace bolts.	II.B.4. Introduce brace bolts.	
a. Two each.		
b. 3/8" x 4 1/2".		
5 Spring washers.	II.B.5. Introduce spring washers.	
a. 3/8" diameter bolt.		
(1) Two each.		
b. 5/8" diameter bolt.		
(1) Five each.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
6. Through-bolt, static-proof.	II.B.6. Introduce bolt and demonstrate how to determine proper length.	
a. 5/8" diameter.		
b. Length.		
(1) Diameter of pole at gain plus 4".	II.B.6.b.(1) End of bolt must not extend past the outer most nut more than 2".	
c. One each.		
7. Square washer, flat.	II.B.7. Introduce washer.	
a. 5/8" diameter bolt.		
b. Five each.		
8. Lag screw.	II.B.8. Introduce lag screw.	
a. 1/2" diameter.		
b. One each.		
9. Pin, insulator.	II.B.9. Introduce pin.	
a. 1" lead thread for insulator.		
b. One each.		
10. Insulator, pin type.	II.B.10. Introduce insulator and demonstrate how to assemble to pin.	
a. 1" thread diameter.		
b. One each.		
11. Stud, line post insulator.	II.B.11. Introduce stud.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. 3/4" thread for insulator.		
b. 5/8" thread shank.		
c. Three each.		
12. Insulator line post, tie top.	II.B.12. Introduce insulator and demonstrate how to assemble to stud.	
a. 3/4" thread for stud.		
b. Three each.		
C. Steps of procedure - single arm.	II.C. Demonstrate measuring diameter of pole at gain.	
1. Determine length of through bolt.		
a. Diameter of pole at gain, plus 4".		
2. Prepare crossarm.		
a. Install brace bolts in crossarm from back side.	II.C.2.a. Demonstrate installation of bolts.	
b. Install flat braces over end of brace bolts.	II.C.2.b. Demonstrate installation of braces.	
c. Install 3/8" diameter spring washers on brace bolts over flat brace.	II.C.2.c. Demonstrate installation of spring washers.	
(1) SNUG 3/8" nut on brace bolts. Do Not tighten at this time.		
d. Rotate flat braces towards center of crossarm, to facilitate handling.	II.C.2.d. Demonstrate rotating braces.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Linemen's position.	II.C.3. **Stress:** Lineman's position on pole facing gain with safety belt even with the bottom of the gain.	
a. Lineman ascend pole and belt-off just below and facing the gain.		
b. Attach handline to pole.		
(1) Timber hitch.		
4. Insert through-bolt in pole.		
a. Groundman: Send the proper length static-proof bolt aloft, via the grunt's bag.		
b. Lineman: Insert bolt from back of pole.	II.C.4.b. Demonstrate insertion.	
5. Send crossarm aloft.		
a. Ensure arm is sent aloft so that the "top" of the arm will face up, and that the braces will be next to the pole.		
6. Linemen receives crossarm.		
a. Linemen: Place crossarm on safety strap.		
(1) Groundman raises arm with handline.		
(2) Linemen guide arm onto your safety belt.		

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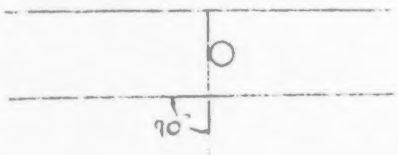
OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
7. Install mechanical gain.		
a. Install mechanical gain on protruding through bolt.	II.C.7.a. Demonstrate proper installation of mechanical gain.	
(1) Concave side towards pole.		
8. Position crossarm on pole.	II.C.8. Demonstrate positioning crossarm on pole.	
a. Rotate flat braces down away from the through-bolt hole.		
b. Guide crossarm over through bolt.		
9. Secure crossarm in position.	II.C.9. Demonstrate securing the crossarm in position.	
a. Install a square washer on through-bolt.		
b. Install a 5/8" spring washer on through-bolt.		
c. Install a 5/8" nut, tighten till nut just contacts the spring washer.	II.C.9.c. Demonstrate tightening nut.	
d. Remove the clove hitch from crossarm.		
e. Align crossarm.	II.C.9.e. Sketch on chalkboard.	
(1) Using a screwdriver, move the mechanical gain to the right or left, so that the arm is at 90° to the direction of the line.		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
f. Level crossarm.		
(1) Put a 24" level on top of arm and level.		
(2) Tighten the through-bolt nut all the way down, with a lineman's wrench then back off 1/4 turn or 90°.		
g. Attach flat braces to pole.	II.C.9.g. Demonstrate bringing flat braces together.	
(1) Bring the two flat braces together on face of pole.		
(2) Drive a lag screw into the 9/16" holes and on into the pole, all except the last 1/2" that must be screwed in using a wrench.	II.C.9.g.(2) Demonstrate lag screw installation.	
h. Secure flat braces to crossarm.		
(1) Using a "lineman's wrench", tighten the nuts on brace bolts till the spring washers are fully compressed.		
(2) Back nut off 1/4 turn or 90°.		
10. Installation of insulators.		
a. Groundman - assemble line post and pin-type insulators as per instructor demonstration.	II.C.10.a. Demonstrate how to assemble a line post and pin-type insulator.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Groundman - Send assembled insulators aloft via the "grunt's bag".		
(1) One in bag at a time.		
c. Lineman - Receive insulators via handline, insert assembled insulators into pin holes as per instructor location.	II.C.10.c. Demonstrate insertion.	
d. Rotate insulator so that the saddle is in the direction of the line.	II.C.10.d. Demonstrate proper position of insulator to line conductor.	
e. Install a 5/8" flat washer on line-post studs on bottom side of crossarm.	II.C.10.e. Demonstrate installation of washer.	
(1) Square with arm.		
f. Install a 5/8" spring washer on studs.	II.C.10.f. Demonstrate installation of spring washer.	
g. Install 5/8" nut and tighten till spring washers are fully compressed.	II.C.10.g. Demonstrate tightening of nut.	
h. Back off nut 1/4 turn or 90°.	II.C.10.h. Demonstrate 90° back off.	
D. Materials required for double arm deadend.		
1. Crossarm.		
a. Two each.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Mechanical gain.		
a. One each.		
3. Flat braces.		
a. Four each.		
b. 28" long.		
4. Brace bolts.		
a. Four each.		
5. Spring washers.		
a. 5/8" diameter bolt.		
(1) Five each.		
b. 3/8" diameter bolt.		
(1) Four each.		
6. Through-bolt, static-proof.	II.D.6. Introduce bolt.	
a. 5/8" diameter.		
b. Length.		
(1) Diameter of pole at gain plus 8".		
c. One each.		
7. Lag screw.	II.D.7. Introduce lag screw.	
a. 1/2" x 4".		
b. Two each.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
8. Double-arming eye bolt.	II.D.8. Introduce bolt.	
a. 5/8" diameter.		
b. Length.		
(1) Diameter of pole at gain plus 8".		
c. Four each.		
(1) One for each conductor to be dead-ended.		
9. Square washer.		
a. 5/8" diameter bolt.		
b. Five each.		
10. Washer nut.	II.D.10. Introduce washer nut.	
a. 5/8" diameter bolt.		
b. Eight each.		
11. Insulator suspension.	II.D.11. Introduce insulator.	
a. 6" diameter.		
b. Seven each.		
(1) One per neutral conductor.		
(2) Two per phase conductor.		
12. Pin, insulator.		
a. One each.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
13. Insulator, pin.		
a. One each.		
14. Stud line post.		
a. One each.		
15. Insulator line post.		
a. One each.		
E. Steps of procedure - double arm- dead-end.		
1. Determine length of through-bolt and D.A. bolts.	II.E.1. Demonstrate measuring of gain.	
a. Measure diameter of pole at gain.		
b. Add 8" to this distance.		
2. Install a washer-nut on each D.A. eye bolt.	II.E.2. Demonstrate installation of washer-nut on eye bolt.	
a. Nut faces eye of bolt.		
b. Installed full length of threads.		
3. Prepare first crossarm.		
a. Install through-bolt in proper hole.	II.E.3.a. Demonstrate installation of through-bolt and installation of washer, spring and nut.	
(1) Install a flat washer on bolt.		
(2) Install a 5/8" spring washer.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(3) Install a 5/8" nut on bolt.		
b. Insert double-arm eye bolts in proper holes.	II.E.3.b. Demonstrate installation of eye bolt.	
(1) Install a flat washer on D.A. bolt.		
(2) Install a 5/8" spring washer on D.A. bolt.		
(3) Install 5/8" nut and tighten.		
(a) Two D.A. eye bolts next to through bolt.		
(4) Install 5/8" nut to within 6" of crossarm face.		
(a) Two outside D.A. eye bolts.		
c. Attach flat braces.		
(1) Install brace bolts in crossarm from back side.		
(2) Install flat braces over end of brace bolts.	II.E.3.c.(2) Stress: Use 7/16" diameter hole.	
(3) Install 3/8" diameter spring washers on brace bolts.		
(4) Install 3/8" nut on brace bolt.		
(a) Snug, not tight.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(5) Rotate braces towards center of arm.		
d. Pre-set 5/8" diameter bolts for second crossarm.	II.E.3.d. Demonstrate proper installation of 5/8" nuts.	
(1) Install a 5/8" diameter nut on each D.A. eye bolt to a distance from the face of the crossarm equal to the diameter of the pole at the gain, minus one inch.		
(a) Diameter of pole 8", install nut on bolt to within 7" of crossarm face.		
4. Prepare second crossarm.		
a. Install flat braces same as before.		
5. Linemen's position.	II.E.5. Illustrate positions on chalkboard.	
a. Lineman #1 - ascend pole and belt-off just below and facing the gain.		
b. Secure handline to pole.		
(1) Use timber hitch.		
c. Lineman #2 - ascend pole and belt-off just below the gain and facing the first lineman.		
6. Send first crossarm aloft (crossarm with D.A. eye bolts).		
a. Clove hitch on bottom.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Finger line on top.		
7. Receiving first crossarm.		
a. Lineman #2: Remove fingerline and position crossarm on safety strap as stated before.	II.E.7.a. Stress: First crossarm goes on back side of pole.	
8. Position first crossarm.		
a. Lineman #2: Remove nut, spring washer and flat washer from through-bolt and place in nut and bolt bag on your belt.	II.E.8.a. Stress: Do not drop nuts and washers.	
b. Insert through-bolt in "through-bolt" hole.	II.E.8.b. Stress: Do not bend bolt.	
c. Drive through-bolt through hole.		
(1) Use lineman's hammer if needed.		
(2) Do not bend bolt.		
9. Install mechanical gain.		
a. Lineman #1: Install mechanical gain on protruding through-bolt.	II.E.9.a. Demonstrate installation of mechanical gain.	
(1) Concave side towards pole.		
10. Lineman #1: Install 5/8" spring washers on the four double-arm bolts.	II.E.10. Stress: Install up to the preset 5/8" nut.	
11. Lineman 1: Install flat washers on the four double-arm bolts.	II.E.11. Stress: Install up to the spring washer.	

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

12. Send second crossarm aloft.

    a. Clove hitch on bottom.

    b. Finger line on top.

13. Receiving second crossarm.

    a. Lineman #1: Remove fingerline and position arm on safety strap.

14. Position second crossarm.

    a. Lineman #1: Place crossarm on through-bolt.

15. Secure crossarm assembly in position.

    a. Lineman #1: Install a square washer on through-bolt.

    b. Install a 5/8" spring washer on through-bolt.

    c. Install a 5/8" nut on through-bolt.

        (1) Tighten till nut contacts spring washer.

    d. Remove handline from second crossarm.

    e. Align crossarm assembly.

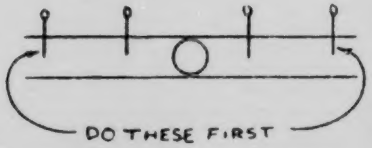
        (1) Using a screwdriver, move the mechanical gain to the right or left so that the arm assembly is at 90° to the direction of the line.

f. Install D.A. bolts in second arm.

(1) Pass the ends of the D.A. bolts through the respective holes.

(a) Start with outside bolts first.

II.E.15.f.(1)(a) Sketch on chalkboard.



(2) Lineman #1: Install 5/8" washer nuts on the D.A. bolts protruding from the second arm.

g. Level crossarm assembly.

(1) Place a 24" level on top of second crossarm and level assembly.

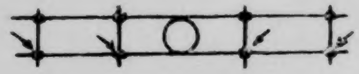
h. Attach flat braces to pole.

(1) Bring the two flat braces together on face of pole.

(2) Drive a lag screw into the 9/16" holes and on into the pole, all except the last 1/2" that must be screwed in using a wrench.

i. Secure flat braces to crossarm.

(1) Using a "lineman's wrench" tighten the nuts on brace bolts till the spring washers are fully compressed.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Back nut off 1/4 turn or 90°.		
j. Secure nut on through bolt.		
(1) Lineman #1: Tighten fully, then back off 1/4 turn or 90°.		
k. Secure nuts on D.A. bolts.		
(1) Lineman #2: Tighten the nuts on inside of first crossarm, tighten fully, then back off 1/4 turn or 90°.	II.E.15.k.(1) Sketch on chalkboard: Tighten these: 	
(2) Lineman #1: Use a 6' folding rule and measure the distance from arm to arm next to pole. Now tighten or loosen the nuts of the second crossarm till the measurement at the end of both arms is the same as the measurement next to the pole.		
16. Installation of suspension insulators.		
a. Groundman: Assemble two 6 inch suspension insulators per phase conductor and one insulator for the neutral conductor.	II.E.16.a. Demonstrate proper way to assemble insulator. "All cotter keys face the same direction".	
b. Groundman: Send ONE insulator assembly aloft at a time via the "grunt's bag".		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Lineman #2: Attach the insulator assemblies to the D.A. eye bolts as per instructor location.	II.E.16.c. Stress: All cotter pins must face the pole.	
17. Installation of line post and pin-type insulators.		
a. Install per instructor location.	II.E.17.a. Stress: Needed only to support phase jumpers.	
b. Install as before.	II.E.17.b. Sketch on chalkboard how jumpers will be trained.	
III. Application.		
A. Student practice - installing crossarms, pins and insulators.	III.A. Assign 4 students to a pole.	III.A. Student practice and complete assigned project to required standards of 100% correct.
IV. Summary.		
A. Job sheet.		
B. Materials required - single arm.		
C. Steps of procedure - single arm.		
D. Materials required - double arm dead-end.		
E. Steps of procedure - double arm dead-end.		
V. Test: None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Guying Poles

Average Time: 2 Periods (Class), 17 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2. NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools and equipment:
   - a. Lineman's tool kit.
   - b. Climbing gear.
   - c. Shovel.
   - d. Tamping bar.
   - e. Cable grip.
   - f. Coffin hoist.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to construct and install guy assemblies using the necessary tools and equipment. Installation will be 100% correct and in accordance with Job Sheet CE "A" JS 2.1.5.1, "Guying Poles".

Criterion Test: The student will assemble and install a guy assembly and an expanding-type anchor. Installations will conform to the tolerance outlined in the job sheet.

Homework: Read: Lineman's and Cableman's Handbook, section 12, pp. 12-1 thru 12-31.

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g. Strand vise hook.

h. Auger truck.

2. Materials:

a. Through-bolts.

b. Guy attachments.

c. Preformed guy grips.

d. Strain insulators.

e. Strand vise.

f. Expanding-type anchor.

g. Anchor rod.

h. Guy wire.

D. Training Aids and Devices:

1. Films:

a. TF-11-2717, "Pole Line Construction, Part V, Installation of Anchors" (12 min.).

b. TF-11-2718, "Pole Line Construction, Part VI, Installation of Guys" (20 min.).

2. Locally Prepared Materials:

a. Guy and anchor display.

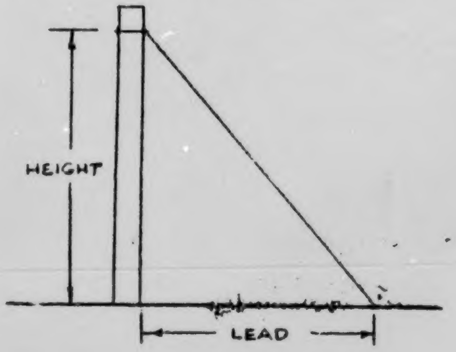
b. Job Sheet.

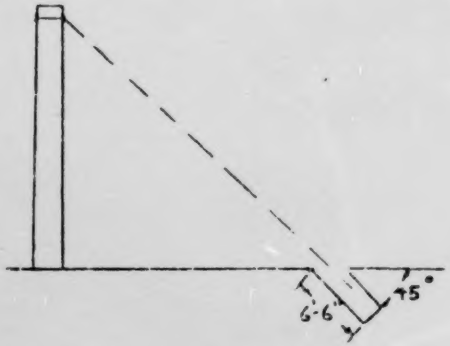
(1) CE "A" JS 2.1.5.1, "Guying Poles".

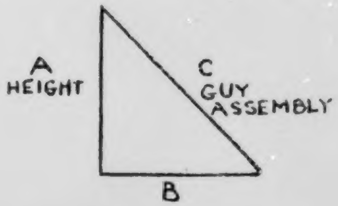
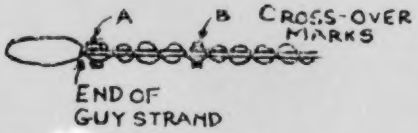
E. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Guying Poles.		
B. Establish readiness:	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Job sheet.	1. State information and materials necessary to guide student.	
2. Steps of procedure.		
3. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet and films.		
1. CE "A" JS 2.1.5.1, "Guying Poles".	II.A.1. Review steps of procedure outlined in the job sheet.	
2. TF-11-2717, "Installation of Anchors".	II.A.2. Show film "Installation of Anchors".	II.A.2. View film.
3. TF-11-2718, "Installation of Guys".	II.A.3. Show film "Installation of Guys".	II.A.3. View film.
B. Steps of procedure.		
1. Digging in the anchor.		
a. Location of hole (distance).	II.B.1.a. Sketch on chalkboard. 	
(1) Guy ratio $\frac{(\text{height})}{\text{lead}}$ Ideal ratio: For every foot of height there should be one foot of lead.		
b. Location of hole (direction).		
(1) Refer to NAVFAC Dwg. 1109831 for position of pole in pole-line for direction that crossarms will be facing.		
(2) Position hole using 2 to 1 ratio.	II.B.1.b.(2) 2 to 1 ratio will be adequate for poleline practical.	
c. Dig hole using auger truck.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Position auger on a 45° angle pointing away from the pole.	II.B.1.c.(1) Instructor will operate the auger truck following all safety rules.	II.B.1.c.(1) Observe the operation of the auger truck.
(2) Depth of hole will depend upon the length of anchor rod. EXAMPLE: 5/8" x 7' rod. Eye of anchor rod shall be approximately 6" above ground. Depth of hole = 6' 6".	II.B.1.c.(2) Sketch on chalkboard: 	
d. Install anchor.		
(1) Use expanding-type anchor in accordance with instructor's demonstration.	II.B.1.d.(1) Demonstrate installation of the expanding-type anchor.	
(2) Fill anchor hole with shoveling and tamping procedures used for filling pole holes.	II.B.1.d.(2) Stress: Opening of anchor eye is facing the ground.	
2. Install "malleable guy attachment" on pole.		
a. Select a through-bolt with length required for the diameter of pole and guy attachment. Installation will be in accordance with the guying detail outlined in NAVFAC Dwg. 1109831.	II.B.2.a. Review with class the detail in the NAVFAC Dwg.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Lineman: Will install the guy attachments on the pole 9" below top crossarm and 9" below second crossarm.	II.B.2.b. Stress: Number of guy attachments depend upon location of guying and guying detail description outlined in NAVFAC Dwg. 1109831.	
3. Assemble "guy assembly" on the ground.		
a. Calculate overall length of guy assembly using Pythagoream Theorem. $C^2 = A^2 + B^2$ or $C = \sqrt{A^2 + B^2}$	II.B.3.a. Sketch on chalkboard.  	
b. Use "C" measurement for length of guy wire. Cut required length, and cut piece in half.	II.B.3.b. Stress: Cutting strand in half will locate the strain insulator in the middle of the guy assembly.	
c. Install "Preformed Guy Grips".		
(1) For attachment to the pole - on top section of guy strand. Long leg of guy grip shall be applied first to its entire length. (Align end of guy strand with Mark "A".) Align cross-over mark "A" of short let with "A". Mark on long leg. Complete installation.	II.B.3.c.(1) Sketch on chalkboard.  Demonstrate: How to install guy grip on a short length of guy strand.	

OUTLINE OF INSTRUCTION

(2) For attachment to the guy strand insulator. Align end of guy strand with Mark "B", wrap long leg. Align "B" of short leg with "B" of long leg. Complete installation.

(3) Install bottom section of guy strand to strain insulator and complete guy grip installation as illustrated in II.B.3.c.(2).

4. Install "automatic dead-end strand-vise" on anchor rod.

a. Disassemble strand vise.

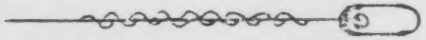
(1) Remove "body" from "yoke" and seperate "yoke" from "bail".

b. Insert bail into eye of anchor rod and reassemble strand vise.

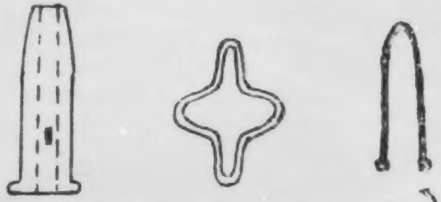
5. Attach "guy assembly" to pole.

INSTRUCTOR ACTIVITY

II.B.3.c.(2) Sketch on chalkboard.



Stress: Ensure that "frost-ring" of strain instulator will be point down when installed.



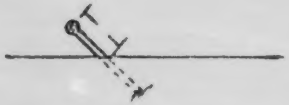
II.B.4.a. Sketch on chalkboard:

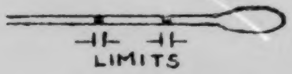
Stress: Final assembly of strand vise should have keeper 90° from bail.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
a. Lineman: Will ascend pole, and belt off close to guy attachment and receive the guy assembly via handline.	II.B.5.a. Demonstrate: How groundman will tie a "grunt's knot" in the eye of the top preformed guy grip.	
(1) Grasp guy assembly with both hands approximately 4 to 6 inches below the preformed eye. Inform groundman to release the grunt's knot by pulling on the handline.		
(2) Place eye of guy grip over the guy attachment.		
(3) Descend the pole.	II.B.5.a.(3) Inform groundman to keep guy assembly away from pole while lineman descends pole.	
6. Attach "guy assembly" to anchor rod.		
a. Insert guy strand through body of strand vise.	II.B.6.a. Demonstrate: When inserting guy strand into strand vise with one hand, remove slack from guy strand with other hand. Stress: The guy strand must be straight and end unfrayed.	
b. Attach "wire grip" (with eye down) approximately 4 feet from strand vise.	II.B.6.b. Ensure that free chain with bottom hook is extended to within 4 - 6 inches of maximum chain length.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Insert top hook of coffin hoist into eye of wire grip.	II.B.6.c. Demonstrate: Proper method of inserting hook of chain hoist into eye of pulling hook. Remove slack from coffin hoist chain.	
d. Insert bottom hook of coffin hoist into eye of strand vise pulling hook.		
7. **Tensioning guy assembly.**		
a. Operate handle assembly of coffin hoist throughout its maximum up-and-down travel.	II.B.7.a. Assistant to coffin hoist operator will guide guy strand into strand vise as tensioning is performed.	
b. An observer positioned 90° from guy assembly axis, and approximately 30 feet from the pole, will inform coffin hoist operator when the top of pole is pulled 4 to 6 inches from dead center.		
c. Place coffin hoist control lever in the "DOWN" position, operate handle as per II.B.7., remove coffin hoist and pulling hook when adequate slack is provided.	II.B.7.c. Personnel assigned to handle coffin hoist will secure it where sand or dirt cannot enter the working parts.	
8. Remove excess guy strand.		
a. Cut end of guy strand with bolt cutters to within 1 - 3 inches of strand vise body.		
	Guy installation evaluation: 1. Eye of anchor rod: 6 inches above ground.	



OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	Guy installation evaluation continued: 2. Ends of guy strand shall be within the limits of appropriate cross-over marks. 3. Strain insulator: Frost ring - facing towards ground. Minimum clearances: Horizontal - from face of pole - 6 feet. Vertical - from finished grade - 8 feet. 4. End of strand: 1 to 3 inches past strand vise body.  	
III. Application.		
A. Student practice - guying poles.	III.A. Assign 4 students to a pole requiring a guy.	III.A. Student practice and complete assigned project to the assigned tolerances.
IV. Summary.		
A. Steps of procedure.		
1. Digging in the anchor.		

OUTLINE OF INSTRUCTION **INSTRUCTOR ACTIVITY** **STUDENT ACTIVITY**

b. Install malleable guy attachment.

c. Assemble guy assembly on the ground.

d. Install automatic dead-end strand vise.

e. Attach guy assembly to pole.

f. Attach guy assembly to anchor rod.

g. Tensioning guy assembly.

h. Remove excess guy strand.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORINA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Stringing Primary Line Conductors

Average Time: 1 Period (Class), 10 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.

2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References:

1. U.S. Department of Commerce, National Bureau of Standards, "Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines".

C. Tools, Equipment and Materials:

1. Tools and Equipment.

   a. Lineman's tool kit.

   b. Climbing gear.

   c. Slings.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW, singly or in parallel. Installations and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install primary line conductors in accordance with procedures and safety precautions outlined in the Job Sheet CE "A" JS 2.1.6.1, "Stringing Primary Conductors". Installation will be done without error.

Criterion Test: The student will install primary line conductors and make the required insulator ties and inter-conductors connections. All procedures will be executed 100% correct.

Homework: Read: Lineman's and Cableman's Handbook, section 15 and 16, pp. 15-1 thru 16-58.

d. Cable grips.

e. Coffin hoists.

f. Handline.

2. Materials:

a. As listed in NAVFAC Dwg. 1109831.

D. Training Aids and Devices:

1. Locally Prepared Materials:

a. Automatic dead-end display board.

b. Job Sheet.

(1) CE "A" JS 2.1.6.1, "Stringing Primary Line Conductors".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Primary Line Conductors.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Primary line hardware.	1. State information and materials necessary to guide student.	
2. Job Sheet.		
3. Steps of procedure.		
4. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Primary line hardware.		
1. "LD" and "LS" Automatic Dead-End Device.	II.A.1. Demonstrate: How device is installed on the end of a conductor.	
a. Always used at dead-end and corner poles to terminate primary conductors.		
b. "LD" type designed with cotter key assembly for securing to bell-type insulator.		
c. "LS" type designed with a stranded bail assembly for securing to bell, or clevis and spool-type insulators.		
2. Compression splice.	II.A.2. Demonstrate: How to make a compression splice using the device, compression tool and two pieces of copper conductor.	
a. Used to join two sections of primary solid conductors.		
3. Tension splice.	II.A.3. Demonstrate: How to make a tension splice using the tension sleeve and two pieces of copper conductor.	
B. Introduce Job Sheet.		
1. CE "A" JS 2.1.6.1, "Primary Line Conductors".		
C. Steps of procedure.		
1. Installation of primary conductors.		
a. Select the pre-determined lengths of #6 AWG medium hard-drawn solid copper conductors (identified coils).		

b. Layout conductor coils by rolling alongside of poles from dead-end to dead-end poles. Leave 6 feet past both dead-end poles.

  (1) Conductors will be positioned on the ground under related insulators on the poles.

c. Lineman: Ascend dead-end pole with line and prepare to receive primary conductors.

d. Groundman: Secure a wire grip jaw to the end of one conductor and secure wire grip to snap of handline. Raise wire grip and conductor to lineman.

  (1) Secure conductor in jaw assembly of wire grip approximately 6' from end. Raise inside conductors first.

e. Lineman: Insert end of #6 conductor into automatic dead-end assembly. Pull in approximately 6 feet. Repeat same procedures for the remaining three conductors.

f. Lineman: Descend dead-end pole and ascend the first pole in line (with handline).

g. Groundman: Place hook of handline on one inside conductor. Raise conductor to the lineman. Repeat with other inside conductor.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

h. Lineman: Place remaining conductors on the inside of the center insulators.

   (1) "Inside of insulators" - side of insulators facing the pole.

i. Lineman: Place remaining conductors on the inside of their respective insulators.

j. Complete raising of conductors on the remaining in-line poles.

k. Linemen (two): Ascend corner pole with a handline and prepare to raise and secure primary conductor ends.

l. Groundman: Secure a wire grip to the end of one outside conductor and secure the other end of wire grip to the snap of handline.

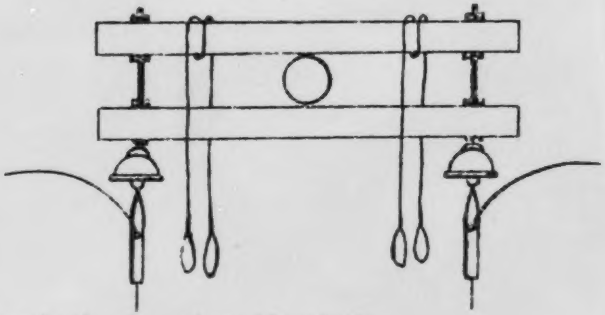
   (1) Secure conductor in jaw assembly of wire grip approximately 3 to 6 feet from end of conductor. Raise outside conductors first before raising center conductor.

m. Lineman: Insert end of each conductor into automatic dead-end assembly. Pull in approximately 4'. Repeat same procedures for all conductors.

2. Sagging primary conductors.

a. Groundman: Select two (2) 4' slings (3/8" steel cable with a standard size eye at each end) and hoist to the lineman.

b. Lineman: Secure slings as per sketch:



(1) Insert hook of each coffin hoist into eyes of slings and secure the chain-end hook into cable-grip attached to each outside conductor.

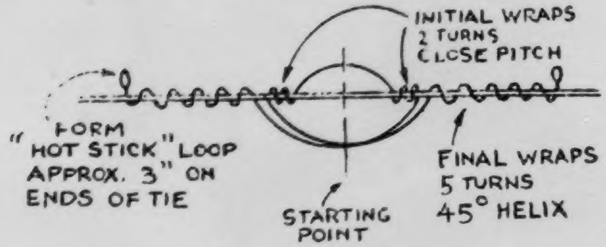
(2) Operate handles of coffin hoists till correct sag is obtained.

II.C.2.b.(2) Sag will be determined by instructor sighting from the ground.

c. During sagging procedure, ensure that each conductor is guided (without kinking through the automatic dead-end).

(1) Conductor should be coming out of the top or bottom of the automatic dead-end in accordance with drawing II.C.2.b.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. After proper sag is obtained on the outer conductors, remove one set of sagging equipment and install on inside conductors.		
e. Perform same sagging procedures as outlined in II.C.2.b. and sag to same configuration as the outside conductors.		
f. Remove equipment after all conductors have been raised and sagged.		
3. Secure primary conductors to pin insulators (make ties).		
a. On all in-line poles conductors will be placed on top of each perspective insulator.		
b. Groundman: Select (for each pole) 4 pieces of 36 inch long, #6 AWG soft-drawn, solid copper conductor.	II.C.3.b. Stress: To utilize nose-bag for hoisting tie-wires to lineman.	
c. Lineman: Follow sketch:	II.C.3.c. Provide classroom training aid for students to make practice ties before making ties on overhead conductors.	II.C.3.c. Practice ties.


INITIAL WRAPS
2 TURNS
CLOSE PITCH
"FORM "HOT STICK" LOOP APPROX. 3" ON ENDS OF TIE
STARTING POINT
FINAL WRAPS
5 TURNS
45° HELIX

SINGLE-PIN TYPE INSULATOR TIE FOR COPPER CONDUCTORS

(1) Complete ties on all poles.

4. Make jumper connections at all corner poles.

   a. Groundman: Compile a list of material required at each pole in accordance with the NAVFAC Dwg. 1109831, "Advanced Base Standard Pole Line".

      (1) Ensure that the required number of split-bolt connectors and jumper wires are on hand before lineman ascends the corner poles.

   b. Lineman: Ascend corner pole and complete the installation of primary conductors in accordance with the drawing.

      (1) Form the jumper wires in a smooth and safe configuration between conductors.

II.C.4.b.(1) Stress: Primary conductors shall be installed and sagged with appropriate ties made on each insulator

NOTE: All work shall be executed 100% correct.

III. Application.

   A. Student practice - install primary conductors for 4160 volt overhead distribution system.

IV. Summary.

   A. Primary line hardware.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

B. Steps of procedure.

1. Installation of primary conductors.

2. Sagging primary conductors.

3. Secure primary conductors to pin insulators.

4. Make jumper connections at all corner poles.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: **Transformers** and Protective Equipment

Average Time: 1 Period (Class), 5 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Materials:

1. Tools and Equipment:
   - a. Lineman's tool kit.
   - b. Climbing gear.
   - c. Pole top gin.
   - d. Block and tackle assembly.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW, single or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install a three-phase transformer bank with associated equipment. Installation will be 100% correct in accordance with the Job Sheet CE "A" JS 2.1.7.1, Transformers and Protective Equipment".

Criterion Tests: The student will install a three-phase transformer bank, fuse cutouts and lightning arrestors. All procedures will be performed 100% correct.

Homework: Read: Lineman's and Cableman's Handbook, section 17, pp. 17-1 thru 17-30.

e. Three single-phase transformers.

f. Fuse cutouts and bracket assemblies.

g. Lightning arrestors and bracket assemblies.

2. Materials:

a. As listed in NAVFAC Dwg. 1109831.

D. Training Aids and Devices:

1. Locally prepared materials:

a. Lightning arrestor and fused cutout display.

b. Job Sheet.

(1) CE "A" JS 2.1.7.1, "Transformers and Protective Equipment".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Transformers and Protective Equipment.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview.	I.D. State learning objectives.	
1. Job sheet.	1. State information and materials necessary to guide student.	
2. Steps of procedure.		
3. Questions.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Introduce job sheet.		
1. CE "A" JS 2.1.7.1, "Transformers and Protective Equipment".		
B. Steps of procedure.		
1. Preparations for installing transformers.		
a. Lineman #1: Ascend transformer pole with handline and prepare to receive the pole top gin.		
b. Lineman #2: Ascend pole and position on opposite side of lineman #1.		
c. Groundman: Attach pole top gin to handline using a "grunt's knot" above the snap and ring. Hoist to lineman.	II.B.1.c. Demonstrate: Tying "grunt's knot" on pole top gin.	
d. Lineman #1: Position pole top gin.	II.B.1.d. Demonstrate: How to install pole top gin on a classroom pole.	II.B.1.d. Observe demonstration.
e. Secure pole top gin in accordance with instructor's classroom demonstration.		
f. Groundman: Select a block and tackle assembly and use handline to hoist gear to lineman #1.		
(1) Ensure that one person holds bottom portion of the block and tackle while groundman hoists assembly to lineman #1.		

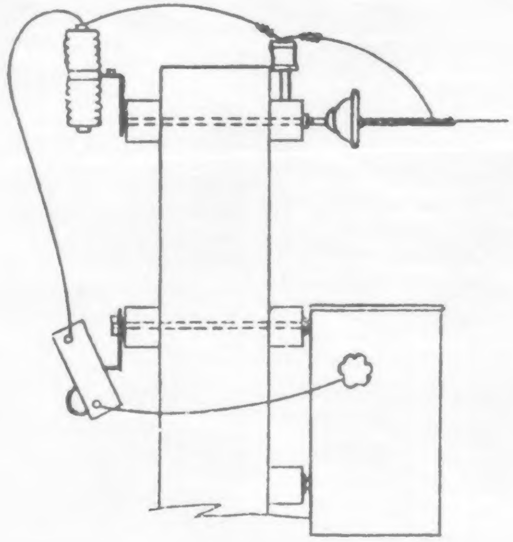
OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
g. Lineman #1: Receive hook of block and insert into eye of pole top gin.		
h. Groundman: Position transformer directly below block and tackle assembly.		
2. Install transformers to step down three phase, 4 wire, 4160 volts.		
a. The following procedures will be used for the installation of three single-phase transformers.		
b. Groundman: Attach tag line around main body of transformer with a timber hitch.	II.B.2.b. Demonstrate: Tying a timber hitch around a transformer. Stress: Tag line required to steady ascent of transformer.	
c. Groundman: Attach a 30 inch sling (with an eye on each end) to the lifting hooks on the sides of the transformer. Insert hook of block and tackle through sling loop.		
(1) Line handler will take up the slack on the block and tackle assembly as soon as hook is engaged in the sling secured to the transformer.		
d. Four (4) men: Two men on the tag line and two on the "fall line" of the block and tackle assembly.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) "Fall line" is the hoisting line coming from the top block.		
e. While two men raise the transformer the handlers tending the tag line will ensure that the transformer is kept away from the pole.		
f. Lineman: With appropriate signals, indicate to the groundman the exact height required for the transformer to be before placing on crossarms.		
(1) First two transformers will be placed on outside of the crossarms. Third transformer will be centered on crossarm.		
g. Lineman: After each transformer is placed in position, remove tag line and secure end to the eyes of sling (while still secured to block and tackle).		
h. Groundman: Lower bottom block by pulling on tag line.		
i. Complete transformer installation using procedures outlined above.		
(1) Position transformers with equal spacing on the crossarms.		
j. Linemen #1 & #2: Lower block and tackle with handline. Disassemble pole top gin from pole and lower with handline.	II.B.2.j. Transformer installation procedures will be executed 100% correct.	

3. Install protective equipment.

   a. Groundman: Select 3 fused cutouts and 3 lightning arrestors, and 6 "L" type brackets for mounting the protective devices. Hoist material to lineman with associated hardware for mounting and securing devices.

   b. Lineman: Install equipment and make connections as follows:



      (1) Outer fused cutouts shall be installed at a slight angle in toward the pole (required for operation of hot stick to open fused cutout).

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

(2) Mount the arrestors first, then reposition yourself on pole to mount fused cutouts in their respective positions. Ensure that all equipment is tightly secured before descending pole.

NOTE: Protective equipment installation procedures shall be executed 100% correct.

III. Application.

A. Student practice - install three single-phase transformers for stepping down 4160 volts to 120/208 volts, 3 phase, 4 wire secondary distribution and protective equipment.

IV. Summary.

A. Job sheet.

B. Steps of procedure.

1. Preparations for installing transformers.

2. Install transformers to step down three phase, 4 wire, 4160 volts.

3. Install protective equipment.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Stringing Secondary Mains

Average Time: 1 Period (Class), 6 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References:

1. U.S. Department of Commerce, National Bureau of Standards, "Safety Rules for the Installation and Maintenance of Electric Supply and Communications Lines".

C. Tools, Equipment and Materials:

1. Tools and equipment.
   a. Lineman's tool kit.
   b. Climbing gear.
   c. Hardhat.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to install the secondary mains for the secondary distribution of power at 120/208 volts. Installation will conform to the job sheet CE "A" JS 2.1.8.1, "Stringing Secondary Mains". Steps of procedure will be performed 100% correct.

Criterion Test: The student will install a secondary distribution system complete with required hardware and materials. Installation procedures will be executed 100% correct.

Homework: Read: Lineman's and Cableman's Handbook, section 5, pp. 5-5 thru 5-15 and section 17, pp. 17-7 thru 17-13.

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d. Secondary distribution hardware.

2. **Materials:**

a. Secondary distribution hardware as listed in NAVFAC Dwg. 1109831.

D. **Training** Aids and Devices:

1. Locally Prepared Material.

a. Secondary main distribution display board.

b. Job Sheet.

(1) CE "A" JS 2.1.8.1, "Stringing Secondary Mains".

E. Training Aids Equipment: None.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Stringing Secondary Mains.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives	
1. Transformer connections.	1. State information and materials necessary to guide student.	
2. Conductor clearances.		
3. Introduce job sheet.		
4. Steps of porcedure.		
5. Questions.		

OUTLINE OF ISNTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. Transformer connections.		
1. Delta-Delta.		
2. Delta-Wye.		
3. Wye-Wye.		
B. Conductor clearances.		
1. From wood.		
2. From equipment.		
C. Introduce job sheet.		
1. CE "A" JS 2.1.8.1, "Stringing Secondary Equipment".		
D. Steps of procedure.		
1. Install secondary distribution system.		
a. Position secondary racks as per sketch on following page:	II.D.1.a. Holes for secondary rack on transformer pole shall be in accordance with the sketch on following page.	

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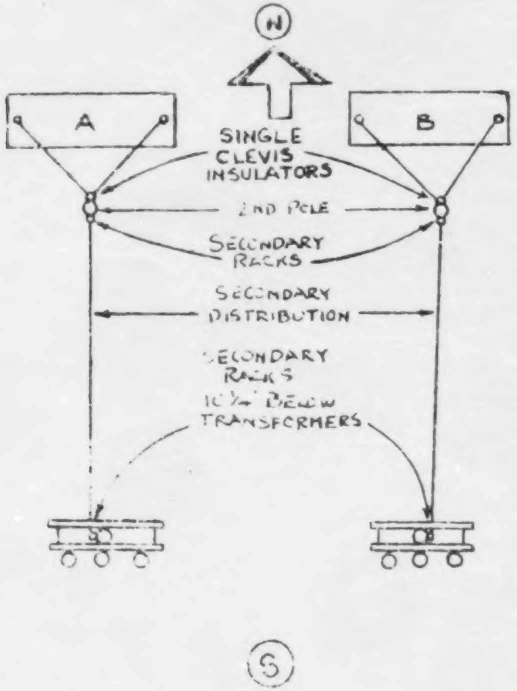
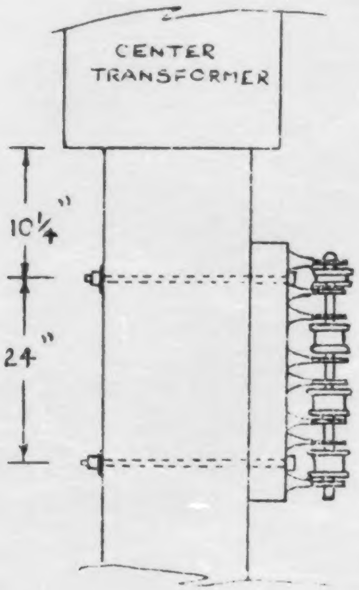
OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY


N
A
B
SINGLE CLEVIS INSULATORS
2ND POLE
SECONDARY RACKS
SECONDARY DISTRIBUTION
SECONDARY RACKS 10¼" BELOW TRANSFORMERS
S


CENTER TRANSFORMER
10¼"
24"

b. Groundman: Select two 4 spool secondary racks with spools.

4 - thru-bolts, length dependent upon pole diameter and 2" exposure.

6 - curved washers.

6 - spring washers.

6 - nuts.

II.D.1.b. For rack installation thru-bolt holes shall be 11/16" diameter for the 5/8" diameter bolts.

4 - pre-cut lengths of #2 AWG insulated stranded copper conductors.

2 - eye bolts.

4 - 3/8" automatic dead-ending devices for #2 AWG triplex stranded conductors.

2 - Pre-cut lengths of #2 AWG triplex (service drop).

c. Lineman: Ascend pole with handline and prepare to receive tools and materials.

d. Lineman: With brace and 11/16" bit, drill first hole for rack a minimum of 10" below transformers. Drill second hole 24" down from center of top rack hole.

  (1) Position of rack on transformer pole as per sketch II.1.a.(note).

e. Groundman: Select secondary rack and disassemble pin and insulator spools. Hoist the disassembled rack with two thru-bolts with an equal number of curved washers, spring washers and nuts to the lineman.

f. Lineman: Place secondary rack over the two thru-bolt holes and align top and bottom rack holes with holes in pole.

  (1) When tightening nut, apply pressure until spring washer is flat, then back off 1/4 turn to allow the spring washer to expand and contract.

(2) Install thru-bolts with bolt head against rack, and apply curved washer, spring washer and nut on opposite end.

g. Groundman: Hoist to lineman the pin and 4 insulator spools. Ensure that pin is complete with a cotter key.

h. Lineman: When installing insulators, position pin in top hole and align one insulator at a time as the pin is being installed. Insert cotter key and spread the ends approximately 1/2".

(1) Make sure that the spools are equally spaced throughout the length of the rack.

i. Groundman: Select the 4 lengths of #2 AWG stranded insulated copper conductors. Roll out each conductor between the two secondary poles. Using the handline, raise the conductors to the lineman, one at a time.

j. Lineman: Secure first conductor to the top spool (secondary system neutral conductor) in accordance with the following sketch and the classroom display.

II.D.1.j. Top hole for secondary rack thru-bolt will be located 10 1/4" from the top of the pole.

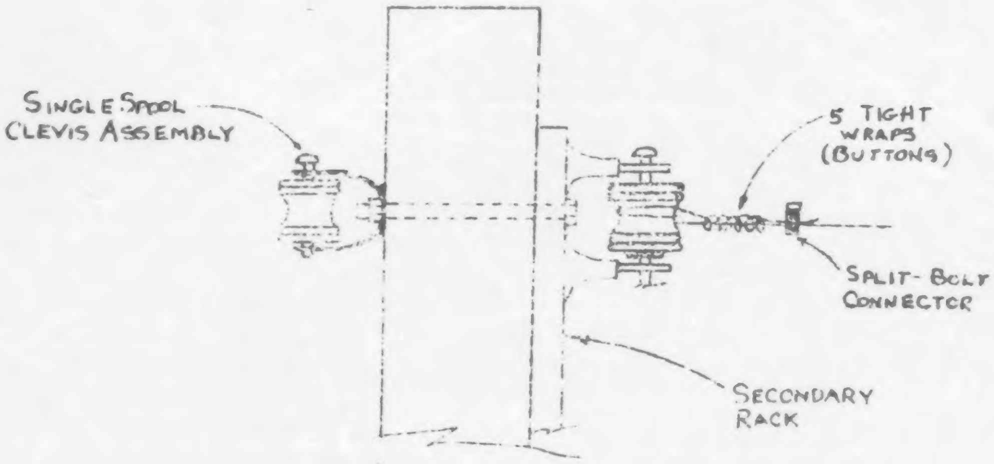
Note: Complete dead-ending of remaining conductors as per sketch.

k. Second pole: Install secondary rack and complete the installation of the secondary distribution system.

2. Installation of "service drop".

a. Groundman: Select a single spool clevis complete with pin, insulator, spring washer and nut. Hoist to lineman.

b. Lineman: Mount the single spool clevis assembly as per following sketch:


SINGLE SPOOL CLEVIS ASSEMBLY
5 TIGHT WRAPS (BUTTONS)
SPLIT-BOLT CONNECTOR
SECONDARY RACK

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Groundman: Select two pre-measured lengths of #2 AWG stranded, insulated aluminum conductors (triplex) and two automatic dead-ending devices. Secure a device on each neutral conductor (approximately 30" back from end). Hoist one end of each service drop to the lineman, one at a time.	II.D.2.c. Demonstrate: How to apply dead-end device on the stranded neutral conductor of the triplex cable.	
d. Lineman: Place both wire bails of dead-ending devices on the single spool insulator, and replace pin and cotter key.		
e. Groundman: Place a dead-ending device on each service drop approximately 12" from end on neutral conductor.		
f. Lineman: Using a tag line, hoist end of triplex with automatic dead-end device and secure to a single-spool assembly mounted on angle iron. Sag cable accordingly by pulling slack thru the dead-end device. Repeat procedure at other service drop.		
g. Lineman: Complete service drop installation by splicing the neutral and phase conductors with split-bolt connectors. Tape each phase splice and leave the neutral untaped.	II.D.2.g. All secondary distribution procedures shall be executed 100% correct.	
III. Practical application.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

A. As a crew member, the student will install a secondary distribution system complete with required hardware and materials. Installation and evaluation will be done in accordance with Job Sheet CE "A" JS 2.1.8.1, "Stringing Secondary Mains".

IV. Summary.

A. Transformer connections.

B. Conductor clearances.

C. Job Sheet.

D. Steps of procedure.

E. Questions.

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NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Transformer Connections

Average Time: 3 Periods (Class), 4 Periods (Pract)

Instructional Material:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.

2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References:

1. U.S. Department of Commerce, National Bureau of Standards, "Safety Rules for the Installation and Maintenance of Electrical Supply and Communication Lines".

C. Tools, Equipment and Materials:

1. Tools and Equipment:

a. Lineman's tool kit.

b. Climbing gear.

2. Materials:

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to connect the three-phase transformer bank to the primary and secondary distribution systems. Connections will be made without error and in accordance with the job sheet CE "A" JS 2.1.9.1, "Transformer Connections".

Criterion Test: The student will connect a three-phase transformer bank to the primary and secondary distribution systems. All connections will be made 100% correct.

Homework: Read: Lineman's and Cableman's Handbook, section 49, pp. 49-1 thru 49-16.

- a. Jumper wires.
- b. Split-bolt connectors.

D. Training Aids and Devices:

1. Films.
    - a. HOW-001, "How Distribution Transformers are Made", (20 min.).
    - b. ITS-001, "It's C.S.P. For Me", (10 min.).
2. Locally Prepared Material:
    - a. Transformer Connection Display Board.
    - b. Job Sheet.
        - (1) CE "A" JS 2.1.9.1, "Transformer Connections".
    - c. Drawing.
        - (1) CE "A" DWG 2.1.9.1, "Primary and Secondary Distribution Jumper Connections".

E. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Transformer Connections.		
B. Establish readiness:	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of materials being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Transformer connections.	1. State information and materials necessary to guide student.	
2. Transformer construction.		
3. Protective equipment.		
4. Introduce job sheet.		
5. Steps of procedure.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

a. Make primary distribution jumper connections at step-down transformer pole.

b. Make secondary distribution jumper connections.

6. Questions.

II. Presentation.

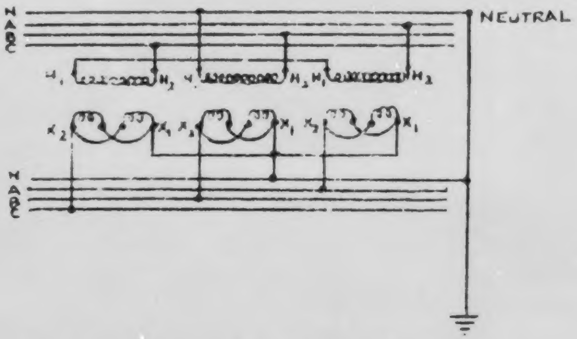
A. Transformer connections.

1. Primary distribution system voltages:

a. Y-Y, 2400/4160 volts.

II.A.1. Indicate the following on chalkboard:

II.A.1. Copy on job sheet.



2. Secondary distribution system voltages:

a. Y-Y, 120/208 volts.

II.A.2. Stress: 120V, single 0 is obtained between neutral and any phase (A, B, or C)
ALSO:
208V., single 0 is obtained between phases A-B, A-C or B-C.
ALSO:
208V., three 0 is obtained by connecting equipment to all three phases (A-B-C).

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
B. Transformer construction.		
1. Film: HOW-001, "How Distribution Transformers are Made".	II.B.1 & II.B.2. Show films and discuss highlight of each.	II.B.1. & II.B.2. View films and participate in discussion.
2. Film: ITS-001, "It's C.S.P. for Me".		
C. Protective equipment.		
1. Lightning arrester.	II.C.1. Display: Mock-up of lightning arrester and associated hardware.	
a. Protects transformer against voltages greater than the normal line voltages.		
b. Furnishes a path to ground to drain off excess voltage (lightning striking primary line).		
2. Primary distribution fused-cutouts.		
a. Protect the primary windings of the distribution transformer against overload or short-circuit.	II.C.2.a. Stress: A fuse is purposely installed as an intentional weak spot in an electrical circuit. Display: Fused cutout and the internal parts (fuse element and connections).	
3. Required clearances for jumper connections.	II.C.3. List on chalkboard examples wood, crossarms pole equipment, flat braces, guy wire, conductors.	
a. From wood - 3".		
b. From equipment - 6".		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

D. Introduce job sheet.

1. CE "A" JS 2.1.9.1, "Transformer Connections".

E. Steps of procedure.

1. Make primary distribution jumper connections at step-down transformer pole.

   a. Lineman: Ascend transformer pole and connect existing 6' ends of each phase conductor to the associated lightning arresters, fused cutouts and transformers in accordance with the attached drawing titled "Lightning Arresters, Fuse Cutouts, and Transformer Connections".

   b. Groundman: Select a 10 foot length of #6 AWG solid hard-drawn, bare copper conductor and hoist to lineman.

   c. Lineman: Connect lightning arresters to existing grounding conductor on pole as per drawing titled, "Primary and Secondary Distribution Jumper Connections".

   d. Groundman: Select two four foot pieces of #6 AWG solid, hard-drawn, bare copper conductors and hoist to lineman

OUTLINE OF INSTRUCTION

e. Lineman: Connect 6' tail of overhead primary neutral conductor to the ground wire connecting lightning arresters. Connection shall be made with split-bolt connector. Secure end of conductor to the nearest H_1 bushing.

f. Complete neutral connection using the two 4 foot pieces of #6 copper between the three H_1 bushings.

2. Make secondary distribution jumper connections.

a. Groundman: Select two four foot pieces of #2 AWG stranded, insulated, copper conductors and hoist to lineman.

b. Lineman: Install the two four foot pieces of jumper wire between the X_2 secondary bushings as per attached drawing.

c. Completion of secondary hook-up shall be in accordance with the drawing titles "Primary and Secondary Distribution Jumper Connections".

(1) Measurements for jumpers shall be made between X_1 bushings and their respective secondary distribution conductors. Ensure that jumpers are installed with the required clearances.

INSTRUCTOR ACTIVITY

II.E.1.f. Stress: That bare high voltage conductors shall maintain the following clearances:
3" - wooden crossarms and poles.
6" - metallic equipment and hardware.

II.E.2.c.(1) Installation of primary and secondary connections shall be performed 100% correct.

STUDENT ACTIVITY

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

III. Application.

A. Student practice - install primary and secondary jumpers and make connections in accordance with Job Sheet CE "A" JS 2.1.9.1, "Transformer Connections and Drawing CE "A" DWG 2.1.9.1, "Primary and Secondary Distribution Jumper Connections".

IV. Summary.

A. Transformer connections.

B. Transformer construction.

C. Protective equipment.

D. Introduce Job Sheet.

E. Steps of procedure.

1. Make primary distribution jumper connections at step-down transformer pole.

2. Make secondary distribution jumper connections.

F. Questions.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Pole Top Rescue

Average Time: 1 Period (Class), 6 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz; McGraw-Hill Book Co., New York, N.Y.

B. References: None.

C. Tools, Equipment and Materials.

1. Tools and equipment.
    - a. Climbing gear.
    - b. Handline.
    - c. Harness with lifeline.
    - d. Blanket.

D. Training Aids and Devices.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to perform pole top rescue procedures while adhering to required safety precautions. Rescue performance will be in accordance with the Job Sheet CE "A" JS 2.1.10.1, "Pole Top Rescue". Steps of procedure will be executed 100% correct.

Criterion Test: The student will perform pole top rescue procedures in accordance with the job sheet CE "A" JS 2.1.10.1, "Pole Top Rescue". Rescue procedures will be executed 100% correct.

Homework: Read: Lineman's and Cableman's Handbook, section 49, pp. 49-1 thru 49-16.

1. Films:

    a. MA-9559, "Resuscitation, Mouth-to-Mouth, Mouth-to-Nose", (23 min.).

    b. POL-001, "Pole Top Rescue and Closed Heart Massage", (10 min.).

2. Locally Prepared Materials:

    a. Job Sheet.

        (1) CE "A" JS 2.1.10.1, "Pole Top Rescue".

E. Training Aids Equipment:

1. 16mm movie projector.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Pole Top Rescue.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. First aid for lineman.	1. State information and materials necessary to guide students.	
a. Films.		
b. Wounds and control bleeding.		
c. Shock.		
d. Artificial respiration.		
e. Burns.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Introduce job sheet.		
3. Steps of procedure.		
a. Perform pole top rescue of an injured lineman.		
4. Questions.		
II. Presentation.		
A. First aid for lineman.		
1. **Films:**	II.A.1. Show films and discuss highlights.	II.A.1. Take notes during discussion.
a. MA-9559, "Resuscitation, Mouth-to Mouth, Mouth-to-Nose", (23 min.).		
b. POL-001, "Pole Top Rescue and Closed Heart Massage", (10 min.).		
2. Wounds and control of bleeding.		
a. Wound is any break in the skin.		
b. Two classes of wounds.		
(1) Severe bleeding.		
(2) Bleeding is not severe.		
c. Control of severe bleeding between the wound and the heart at the pressure point nearest the wound.	II.A.2.c. Demonstrate: Ask for a student volunteer, point out where the arterial pressure points are on his body and head.	

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(1) Apply pressure with fingers at the following locations.

(a) At the temple in front of the ear against the skull.

(b) About an inch forward from the angle of the lower jaw.

(c) In the neck at the side of the wind pipe, against the backbone.

(d) Behind the inner end of the collarbone, down against the first rib.

(e) On the inner side of the upper arm, halfway between the shoulder and elbow.

(f) On the inner side of the thigh about four inches below the groin.

d. Control of not severe bleeding.

(1) Apply antiseptic, sterile dressing and a bandage firmly in place.

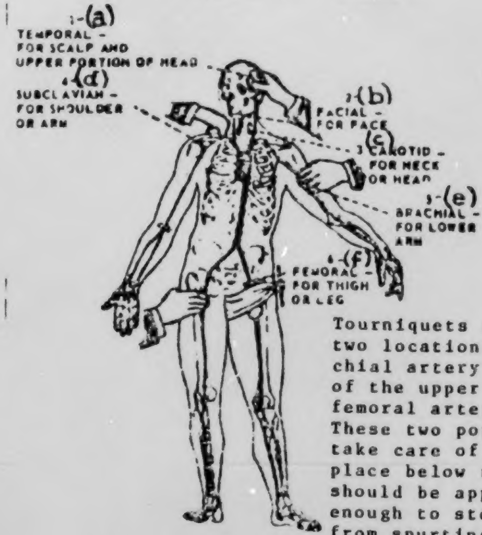
3. Shock.

a. A disturbance of the nervous system resulting in a depressed state of all body functions due to lack of proper circulation. The more serious the injury, the more severe the shock.

II.A.2.c.(1) Refer to following sketch for pressure points:

BLOOD PRESSURE POINTS

for the Control of Bleeding


1-(a)
TEMPORAL - FOR SCALP AND UPPER PORTION OF HEAD
4-(d)
SUBCLAVIAN - FOR SHOULDER OR ARM
2-(b)
FACIAL - FOR FACE
(c)
3 CAROTID - FOR NECK OR HEAD
5-(e)
BRACHIAL - FOR LOWER ARM
6-(f)
FEMORAL - FOR THIGH OR LEG

Tourniquets are useful in two locations: On the brachial artery about the middle of the upper arm and on the femoral artery in the groin. These two points should take care of bleeding at any place below them. Pressure should be applied tight enough to stop the blood from spurting and should be released every 15 minutes; if bleeding starts again, the bandage should be tightened.

b. Symptoms.

(1) Face is pale.

(2) Skin is cool and clammy with perspiration around the nose, mouth and forehead.

(3) Pulse - fast and weak.

(4) Eyes - lack luster and pupils may be dilated.

(5) Breathing - shallow and irregular.

(6) Dizziness, nausea and vomiting may occur.

(7) In severe cases, unconsciousness may develop.

c. Treatment.

(1) Keep injured lying down, his head level with his body.

(2) Keep warm, conserve body temperature.

(3) If conscious, give hot tea or coffee in small quantities.

(4) If injured becomes nauseated, discontinue liquid.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Artificial respiration.		
a. In all cases of ASPHYXIA, (drowning, hanging, gas poisoning, electric shock) the heart usually continues to function for an undetermined period of time. Artificial respiration started immediately during this interval may save a life.	II.A.4.a. Explain: ASPHYXIA - the extreme condition caused by lack of oxygen due to interference with respiration.	
5. Burns.		
a. Injuries caused by dry heat, fire, electricity, hot solutions, steam and chemicals such as acids or alkalis. Electricity may cause burns either by current passing through the body or by an electric flash.		
b. Classification:		
(1) First Degree - reddening of the skin.		
(2) Second Degree - the formation blisters.		
(3) Third Degree - deeper destruction of tissue such as charring.		
c. Treatment.		
(1) Immerse burned area in ice water until pain subsides.		
(2) Use wet packs soaked in ice water - keep wet by gently pouring ice water over pack.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(3) Minor burns.

(a) Apply medication to a sterile dressing and place over burn.

(b) Apply bandage lightly.

(4) Major burns.

(a) Apply sterile dressing and cover with a blanket or other suitable material.

(b) Treat for shock.

(c) Do not attempt to remove charred particles of clothing from burned area.

B. Introduce job sheet.

1. CE "A" JS 2.1.10.1, "Pole Top Rescue".

II.B.1. Issue job sheets.

C. Steps of procedure.

1. Perform pole top rescue of an injured lineman.

a. Rescuer #1: Make a quick survey of the victim's accident situation and ensure that a rescue can be safely accomplished in a short period of time.

II.C.1.a. Situation - rescuer #1 will be working with intended victim on the pole at the time of the simulated accident.

(1) Victim in contact with overhead conductor - use nonconducting material to clear from electrical contact.

OUTLINE OF INSTRUCTION — INSTRUCTOR ACTIVITY — STUDENT ACTIVITY

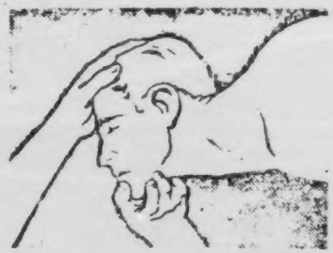
(a) Speed is important, but the rescuer shall take all precautions for his own safety.

(2) Assume a position on the pole next to victim so that you can swing his body over your safety strap.

(a) Victim's body shall be positioned face up on the safety strap.

(3) The victim's head should be tilted into maximum extension by pressing upward on jaw with one hand and push the crown of the head back with the other hand.

II.C.1.a.(3) Demonstrate: Use volunteer to show the following:



(4) Take a deep breath and seal your mouth across the victim's mouth and breathe air into his lungs.

(5) When victim's chest expands, remove your mouth and listen for escaping air.

II.C.1.a.(5) Stress: If stomach bulges press gently to remove excess air.

(6) Continue rescue breathing at the rate of 12 to 15 breaths per minute.

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

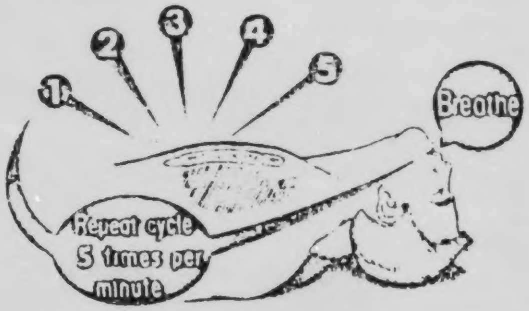
b. Rescuer #2 - After victim is positioned across rescuer #1's safety strap, proceed to climb to a position directly under the victim in order to apply "external heart resuscitation".

II.C.1.b. Explain: This procedure should be applied when there is absence of a heartbeat or pulse.

(1) Position your arms around upper chest of the victim and locate the lower half of the breast bone just below it's center.

(2) Place both hands on this position with the thumb end of clenched fist against breast bone, and other hand applying pressure over clenched fist.

II.C.1.b.(2) Demonstrate as per sketch.



c. Rescuer #1 - after each period of 5 pressure strokes, (by rescuer #2) apply 2 rescue breaths.

d. Continue chest resuscitation cycles until the victim is revived.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Rescuer #1 - when victim is revived and breathing on his own, prepare to lower him.	II.C.1.e. Note: If rescue harness is not available the handline should be used by passing snap hook through both "D" rings and snap onto first "D" ring passed through, demonstrate.	
(1) Signal to groundman to hoist the rescue tackle and harness.		
(2) After receiving harness (with lifeline attached) throw over crossarm and place on victim.	II.C.1.e.(2) Demonstrate: On classroom pole and crossarm.	
(a) When harness is on the victim, the ground crew (3 men) will take a strain on the lifeline to relieve the weight on rescuer #1's safety strap. Ground crew will strictly adhere to the commands from rescuers #1 and #2.		
f. Rescuer #1 - swing victim into a safe position for lowering to the ground.	II.C.1.f. Rescuer #2 will assist in positioning victim for lowering to ground.	
(1) Signal to ground crew to begin lowering.		
(a) Ensure - that handline will not slip off the crossarm. Pin insulator shall be installed near end of crossarm.		

(2) Ground crew will lower victim slowly and gently using hand over hand method on the lifeline.

(3) Lifeline is guided by rescuer #1 and #2, to maintain victim's descent to the ground in a safe manner.

(4) Place victim on a blanket and cover him after releasing harness.

II.C.1.f.(4) All steps of procedures shall be executed 100% correct.

III. **Application.**

A. **Student practice - perform pole top rescue in accordance with steps of procedure in outlined in job sheet CE "A" JS 2.1.10.1 "Pole Top Rescue".**

IV. Summary.

A. First aid for lineman.

1. Films.
2. Wounds and control of bleeding.
3. Shock.
4. Artificial respiration.
5. Burns.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

B. Introduce job sheet.

C. Steps of procedure.

1. Perform pole top rescue of an injured lineman.

V. Test: None.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Power Plants

Average Time: 2 Periods (Class), 7 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 8.

B. References: None.

C. Tools, Equipment and Materials:

1. Equipment.
   - a. Generators - 120/208V, 3 phase, 4 wire.
     - (1) 3-15 KW.
     - (2) 4-100 KW.
     - (3) 1-150 KW.
     - (4) 1-200 KW.
   - b. Load bank:
     - (1) 250 KW resistor-type.
   - c. Switchboard and associated equipment.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to operate a power plant housing generators of varying capacities up to 200 KW. Generators will be operated singly or in parallel in accordance with procedures outlined in the job sheet CE "A" JS 2.1.11.1, "Power Plants". Operating Procedures will be performed without error.

Criterion Test: The student will perform prestart checks and operate generators either singly or in parallel. All procedures will be executed 100% correct.

Homework: Read: Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 8, pp. 177-196.

2. **Materials:**

    a. Diesel fuel.

    b. Crankcase oil.

    c. Distilled water.

D. **Training Aids and Devices:**

1. Locally Prepared Material.

    a. Job Sheet.

        (1) CE "A" JS 2.1.11.1, "Power Plants".

E. **Training Aids Equipment:** None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Power Plants.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Introduction to power plants.	1. State information and materials necessary to guide student.	
2. Job sheet.		
3. Power plant operation.		
4. Questions.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

II. Presentation.

   A. Introduce topic.

      1. Power plants.

         a. Advanced base.

         b. Permanent base.

         c. Combat areas.

         d. Temporary power for new construction.

         e. Emergency power.

   B. Introduce job sheet.

      1. CE "A" JS 2.1.11.1, "Power Plants".

   C. Steps of procedure.

      1. Prestart check of generators, prime movers, and equipment. (Two 15 KW units.)

         a. Fuel tanks - verify that fuel tanks are full by reading level on fuel tank dipstick, or fuel gauge.

         b. Crankcase - check by reading level on dipstick.

         c. Radiator - check water level and add if required.

         d. Batteries - check liquid level and add distilled water if required to prescribed level.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Generator circuit breaker - (located on each generator.) Place in the "OFF" or "OPEN" position.		
f. Voltage regulator switch - Place switch in the MANUAL position and rotate field control knob to the maximum decrease position.	II.C.1.f. Prestart checks shall be executed 100% correct.	
2. Starting prime mover.		
a. Locate speed control and position half way between its minimum and maximum position.		
b. Locate engine - start - switch and depress to activate the battery operated cranking motor. When engine is running, place switch to the UP (run) position.		
(1) Check lubricating oil pressure gauge. If no pressure after 10 seconds, stop the engine by pulling the STOP-CONTROL handle out all the way.		
c. Adjust speed control or frequency control vernier knob until the frequency registers 60 Hertz.		
d. Adjust voltage regulator rheostat until the A.C. voltmeter indicates 208 volts.	II.C.2.d. Stress: On most generators, the output voltage is derived from a 3 phase, 4 wire wye configuration, or phase-to-phase (208 volts) and phase-to-ground (120 volts).	

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Recheck all meters for correct frequency, voltage, oil pressure, water temperature and battery charging ammeter.		
f. When all systems appear normal, place voltage regulator in the automatic position and adjust voltage to 208 volts.	II.C.2.f. Prime movers should be up to operating temperatures before applying load. Cold application of load can cause damage to both generator and prime mover.	II.C.2.f. Practical performance: Prestart checks shall be executed 100% correct.
3. Apply resistor load to generator (for single operation).		
a. Check main breaker on the load bank. (Place in the OFF position.)	II.C.3.a. Stress: If this breaker is in the ON position when the switchboard circuit breaker is placed in the ON position, the generator circuit breaker will trip.	
b. Place the generator circuit breaker to the ON or CLOSED position.		
c. Place the switchboard circuit breaker to the ON or CLOSED position.		
NOTE: The load bank cooling fan warning signal will operate for approximately 2 seconds.		
d. Place the switchboard buss-tie breaker in the CLOSED position by pressing the CLOSED (black button).	II.C.3.d. Stress: The buss-tie breaker requires power to operate electrically - therefore, both the switchboard and generator breakers on the operating unit must be in.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Place the load bank main circuit breaker in the ON position and check voltage on load bank voltmeter and frequency meter.		
f. Apply small load of 7 KW to warm the generator and activate the governor and voltage regulator. Check and adjust volts and Hertz if required.	II.C.3.f. The 7 KW resistor load will indicate approximately 33.6 amps. (Run at this load for approximately 5 minutes.) Applying the load by the student will be closely supervised by the instructor.	
g. Apply additional load of 10 KW for a total of 17 KW - a 2 KW overload. Check readings and run unit on overload for approximately 2 - 5 minutes.		
h. Reduce load by disconnecting 7 KW, and prepare second generator for parallel operation.	II.C.3.h. Second 15 KW unit should be up to operating temperature and ready for parallel operation.	
i. Check volts and amps across all phases by turning the appropriate selector switches.	II.C.3.i. Volts and amps should read the same across all phases.	
j. Check water cooling and lube oil pressure on both units.		
4. Parallel operation (for 2 15 KW units).		
a. Place generator main breaker to ON position on No. 2 unit.	II.C.4.a. This will connect 2nd unit to main buss for parallel operation.	
b. Place the synchronizing lamp switch (on the power unit to be paralleled) in the ON position.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Turn the vernier knob on #2 unit until both units are operating at approximately the same frequency. The synchronizing lamps will glow and go out at a very slow rate.	II.C.4.c. When equal speed is obtained, the matching frequencies will be indicated by the slow change in the brilliance of the synchronizing lamps.	
d. Stand by the switchboard breaker (for the generator to be paralleled) and wait until lamps go out. At that moment, place the breaker in the ON position.	II.C.4.d. Time the dark interval, then in the middle of this interval, place the circuit breaker in the ON position.	
e. Adjust vernier knob (on No. 2 unit) to increase speed to share 1/2 of the 10 KW load. Check Hertz, volts and amps on the two units, and insure that the load is equally distributed.		
5. Securing parallel operation.		
a. On No.2 unit, disconnect switchboard circuit breaker, disconnect generator circuit breaker, place voltage regulator switch to the manual position decrease voltage to "0", slow engine (with vernier) to idle speed, pull engine stop knob all the way, after engine stops, push knob all the way in.		
b. Disconnect 10 KW load and main circuit breaker on the load bank.		
c. OPEN the buss-tie breaker (red button).		
d. Place the switchboard circuit in tne OFF position.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Place the generator main breaker in the OFF position.		
f. Place the voltage regulator switch to the MANUAL position and decrease voltage to "0".		
g. Slow engine (with vernier) to idle speed, pull engine stop knob all the way out. After engine stops, return knob to normal start position.	II.C.4.g. Before securing either unit (after students have completed their practical performance) allow for cooling time to lower temperatures for approximately 15-20 minutes.	II.C.4.g. Practical performance: Single and parallel resistor load operating and securing procedures shall be executed 100% correct.
III. Application.		
A. Student practice.		
1. Prestart checks.		
2. Operate one generator unit.		
3. Operating two in parallel with load.		
4. Securing procedures.		
IV. Summary.		
A. Introduction to power plants.		
B. Job sheet.		
C. Power plant operations.		
D. Questions.		
V. Test None.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Systems Testing

Average Time: 1 Period (Class), 2 Periods (Pract

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 4.

B. References: None.

C. Tool, Equipment and Material:

1. Lineman's tool kit.
2. Climbing gear.
3. **Vibroground** test meter (ground-o-meter).
4. Simpson 260 (Multimeter).
5. Clamp-on ammeter-voltmeter.

D. Training Aids and Devices:

1. Locally Prepared Material:

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system rated up to 5000 volts, and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to conduct various tests on transformer secondaries and check systems grounds. Ground checks will be performed while the system is de-energized, and the secondary systems testing will be conducted while systems are energized by the power plant. Testing and ground check procedures as outlined in Job Sheet CE "A" JS 2.1.12.1, "Systems Testing" will be executed 100% correct.

Criterion Test: The student will conduct various tests on transformer secondaries for voltage and current, and check systems grounds. Tests will be conducted while systems are energized. Ground checks will be made when systems are de-energized. All procedures will be executed 100% correct.

Homework: Read: Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 4, pp. 41 - 74.

a. Job sheet.

(1) CE "A" JS 2.1.12.1, "Systems Testing".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Systems Testing.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Test equipment.	1. State information and materials necessary to guide student.	
a. Vibroground.		
b. Multi-meter (Simpson 260).		
c. Clamp-on ammeter-voltmeter.		
2. Job sheet.		

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Steps of procedure.		
4. Questions.		
II. Presentation.		
A. Test equipment.		
1. Vibroground.		
a. Null-balance principle.	II.A.1.a. The voltage drop developed by a current flowing through the unknown ground resistance is measured by comparing it to a portion of the voltage drop developed by that same current flowing through a calibrated potentiometer.	
b. To check man-made grounds.	II.A.1.b. Grounds protect electrical systems and specific electrical equipment from damage or destruction by voltages from other circuits, or lightning.	II.A.1.b. Take notes.
c. Operation.		
(1) The current flowing through the calibrated potentiometer causes a voltage drop which is fed to the primary of the ratio transformer, inducing a voltage drop in the secondary causing a current flow in the measuring circuit.		

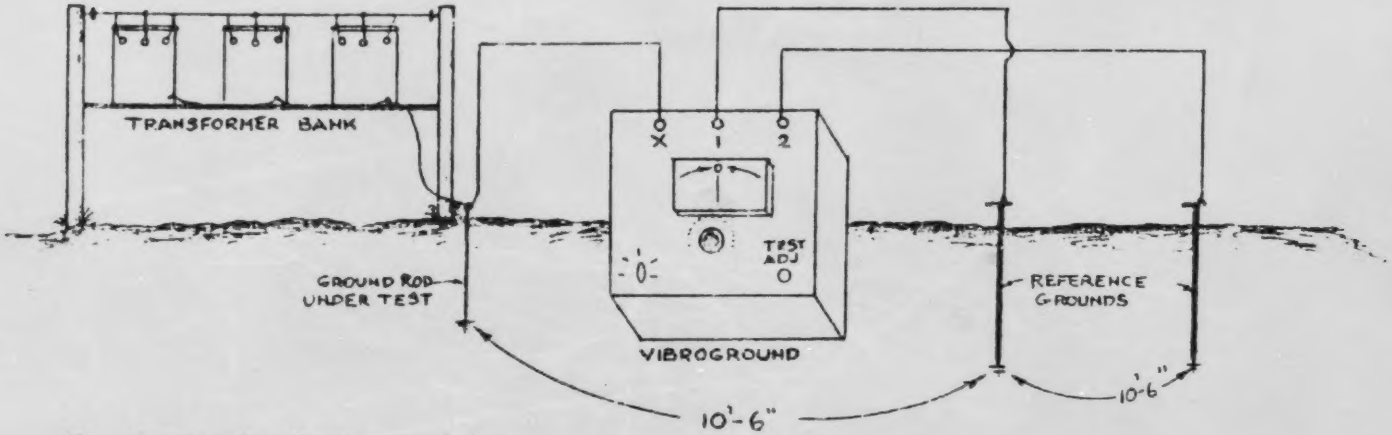
OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) This current cancels the current in the measuring circuit due to the voltage drop across the ground resistance between the electrodes connected to terminals X and 1.		
(3) When the potentiometer and range switch are adjusted so that the two currents exactly cancel, the galvanometer needle will rest in the zero position.		
2. Multimeter (Simpson 260).		
a. Voltmeter dial setting.	II.A.2.a. Always start at highest meter range. This practice protects the meter from injury if an attempt is made to read a high value in a low range.	
(1) To check voltage at distribution panels - phase-to-phase and phase-to-ground.		
3. Snap on ammeter.		
a. To check secondary distribution mains, service drops and individual dwelling circuits.	II.A.3.a. Use highest scale when starting test.	
4. Safety.		
a. Adhere to all safety procedures when using test equipment.	II.A.4.a. Stress: Safety requirements for each piece of equipment.	
B. Introduce job sheet.		
1. CE "A" JS 2.1.12.1, "Systems Testing".	II.B.1. Pass out job sheet and have students follow instructor presentation.	

OUTLINE OF INSTRUCTION

2. Check primary, secondary and service grounds (before energizing system) using vibroground test equipment.

   a. Locate primary step-up transformer bank-driven ground rod.

   b. Set up the two reference grounds as per sketch:


TRANSFORMER BANK
X
1
2
TEST ADJ
GROUND ROD UNDER TEST
VIBROGROUND
REFERENCE GROUNDS
10'-6"
10'-6"

      (1) Use leather hammer to drive reference grounds. Leave approximately 1 1/2" of top of each rod exposed above ground.

   c. Attach jumper wires and make connections as per sketch II.B.2.b.

INSTRUCTOR ACTIVITY

II.B.1.a. Show vibroground test equipment:

STUDENT ACTIVITY

II.B.1.a. Students follow job sheet outline.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
d. Set "range selector" on vibroground test set to the multiply by 10 scale.	II.B.2.d. Explain functions of vibroground controls: (1) Ground connections - Terminals X is always connected to the ground rod to be tested. Terminals 1 and 2 are reference grounds. (2) Balance meter - Shows balance point for taking readings. Arrows indicate direction to turn potentiometer. (3) Balancing potentiometer - Gives true ground resistance reading to 0.1 OHMS times range multiplier when knob is turned to obtain a balanced needle. (4) Range selector - Multiply by 1-10-100-1000. Example: Potentiometer reads 1.8 Range selector is on 10 Solution - 1.8 x 10 = 18 OHMS. (5) Operating lever switch - Pressed upward, it energizes instrument at reduced sensitivity, pressed downward, gives maximum sensitivity for final adjustment of balancing potentiometer. "Spring return protects instrument against accidentally being left on between measurements.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
e. Operate "lever switch" to UP or ADJ position.		
f. Set "balancing potentiometer" to a point where needle is in the center position.	II.B.2.f. Explain arrows on dial will show the direction to move the knob when required.	
g. Place "operating lever switch" into READ position and readjust potentiometer if required.		
h. Multiply reading by 10 and notify instructor if resistance is more than 3 OHMS.	II.B.2.h. Grounding requirement for substations and switching stations on primary systems shall not exceed 3 OHMS.	
i. Perform ground checks on secondary transformer pole and dwelling service.	II.B.2.i. Stress safety requirements - when working with vibroground test equipment.	
(1) Follow steps of procedure outlined in items 1.a. through 1.h.	(1) Do not drop test set.	
	(2) Do not operate "Operating Lever Switch" for extended periods of time.	
	(3) Do not drive reference ground rods to more or less than 1 1/2" out of the ground.	
	(4) Do not exceed 10' 6" between rods.	
3. Energize power plant.		
a. Follow procedures outlined in topic 2.1.11, Job Sheet CE "A" JS 2.1.11.1, Power Plants.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Check voltage at dwelling distribution panels: Phase-to-phase and phase-to-ground.	II.B.4. Stress to ensure that proper voltage from transformers are found.	
a. Select a multimeter and set the following range 0-250 volts.	II.B.4.a. On secondary distribution you will be reading voltages less than 250 volts.	
b. Secure multimeter in a position above the distribution panel.	II.B.4.b. Eye height for easy viewing and to ensure against dropping.	
c. If the approximate voltage of the circuit to be tested is unknown, start with the highest voltage range.	II.B.4.c. Highest range would be 1000V. If reading is approximately 240V move selector to 250V scale.	
d. Make the following voltage checks and record the readings:		
(1) With test leads across the two incoming hot leads, read and record voltage.		
(2) With test leads, read across each hot lead and ground. Record each reading.		
e. Return multimeter to tool room.		
5. Check amperage at the secondary distribution mains, service drops and individual dwelling circuits.	II.B.5. Stress to ensure proper balancing of load across transformer secondaries.	
a. Select a clamp-on type ammeter-voltmeter.	II.B.5.a. Amprobe scales as follows: Ammeter - 0 to 6-15-40-100-300. Voltmeter - 0 to 150-300-600.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. Don climbing gear and ascend the secondary distribution transformer pole.	II.B.5.b. Inform student to clamp ammeter on to tool holder on belt.	
c. Assume a working position between the 4 spool secondary rack and the single spool clevis assembly.	II.B.5.c. Set meter on the 0-100 ammeter scale before using.	
d. Check each phase conductor and neutral on the secondary distribution system.	II.B.5.d. If reading is less than 40, move to 0-40 scale. If less than 15 move to 0-15.	
e. Inform a recorder on the ground of ammeter readings on each hot phase and neutral.		
f. Check each service drop for amperage readings at the drip loops.		
(1) Inform recorder of ammeter readings on West and East service drops.		
g. Descend transformer pole and prepare to take readings at the interior distribution panels.		
h. Place the main disconnect in the OFF position.		
(1) Start with either West or East panel.		
i. Position each branch circuit conductor with a loop for accessible operation of the clamp on ammeter.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
j. Place the main disconnect in the ON position.		
k. Check each branch circuit and record ammeter readings.	II.B.5.k. Repeat same procedures with remaining panel.	
l. Add ammeter loads of individual branch circuits and compare with the load readings on the main secondary distribution conductors.	II.B.5.l. All circuit checking procedures shall be executed 100% correct.	
6. Demonstrate use of vibroground, multimeter and clamp-on ammeter-voltmeter.		
III. Application.		
A. The student will practice taking readings with the vibroground, multimeter and snap-on ammeter-voltmeter in accordance with procedures outlined in the job sheet CE "A" JS 2.1.12.1, "Systems Testing".		
IV. Summary.		
A. Test equipment.		
1. Vibroground.		
2. Multimeter (Simpson 260).		
3. Snap-on ammeter-voltmeter.		
B. Job sheet.		
C. Steps of procedure.		
D. Questions.		
V. Test: None		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

Classification: Unclassified

Topic: Disassemble poleline

Average Time: 1 Period (Class), 10 Periods (Pract)

Instructional Materials:

A. Texts:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.

B. References: None.

C. Tools, Equipment and Material:

1. Lineman's tool kit.
2. Climbing gear.
3. Handline.
4. Tagline.
5. Wire grips.
6. Pole-top gin.
7. Block and tackle.
8. Reel holder and 2 reels.

Terminal Objective: Upon completion of this unit the student will be able to install an overhead distribution system up to 5000 volts, and operate alternating current generators up to 200 KW, singly or in parallel. Installation and operation will be performed in accordance with appropriate job sheets.

Enabling Objectives: Upon completion of this topic the student will be able to disassemble the primary and secondary distribution systems, and associated materials and equipment. Disassembly and storage of materials will be done in accordance with the Job Sheet CE "A" JS 2.1.13.1, "Disassemble Poleline". Steps of procedure will be done without error.

Criterion Test: The student will disassemble the primary and secondary distribution systems, and associated materials and equipment. All work will be done in accordance with the Job Sheet CE "A" JS 2.1.13.1, "Disassemble Poleline", and will be performed 100% correct.

Homework: None.

D. Training Aids and Devices:

1. Locally Prepared Materials:

a. Job Sheet.

(1) CE "A" JS 2.1.13.1, "Disassemble Poleline".

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Disassemble Poleline.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Construction Electrician.		
D. Overview:	I.D. State learning objectives.	
1. Introduce job sheet.	1. State information and materials necessary to guide student.	
2. Steps of procedure.		
a. Remove primary conductors from fused cutouts at platform-mounted transformer bank.		
b. Disconnect and remove primary and secondary jumper wires at the secondary distribution transformer pole.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
c. Remove service drops, secondary mains and associated hardware.		
d. Remove primary conductors between transformer pole and corner pole.		
e. Remove lightning arresters, pin insulators, fused cutouts and dead-end clevis assemblies at the transformer pole.		
f. Remove transformers (secondary distribution).		
g. Remove remaining primary conductors.		
h. Remove guys and guying hardware.		
i. Remove hardware and crossarms.		
II. Presentation.		
A. Introduce job sheet.		
1. CE "A" JS 2.1.13.1, "Disassemble Poleline".	II.A.1. Handout job sheets.	II.A.1. Have students follow instructor's presentation.
B. Steps of procedure.		
1. Remove primary conductors from fused cutouts at platform-mounted transformer bank.		
a. Lineman: Ascend platform assembly and assume a position to disconnect primary conductors from bottom terminals of fused cutouts.	II.B.1.a. Stress: This initial disassembly procedure will ensure against the possibility of accidentally energizing the line.	

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Disconnect and remove primary and secondary jumper wires at the secondary distribution transformer pole.		
a. Lineman: Ascend transformer pole with handline secured to belt.		
(1) Secure handline above top crossarm.		
b. Groundman: Hoist the lineman's kit of tools required to disconnect jumper wires.		
c. Lineman: Disconnect and remove primary and secondary jumper wires, and jumper wire's inter-connecting the transformers.	II.B.2.c. All jumper ties, jumper wires and hardware shall be lowered to the ground using the "Grunt" bag. "DO NOT DROP ANYTHING TO THE GROUND"	
3. Remove service drops, secondary mains and associated hardware.		
a. Lineman: Disconnect service drops from secondary distribution mains.		
(1) Remove neutral (of tri-plex cable assembly) from the single-spool clevis assembly. Lower end of cable to ground with handline.	II.B.3.a.(1) Direct ground crew to complete removal of tri-plex and to coil and stow.	
(2) Remove single-spool clevis assembly and lower to ground.		
b. Lineman: Remove and lower each secondary conductor.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Remove secondary rack and lower with handline.		
4. Remove primary conductors between transformer pole and corner pole.		
a. Groundman: Select a "wire grip" and raise to lineman.		
b. Lineman: Apply wire grip on outside conductor. Secure clip end of handline to wire grip. Notify ground crew to take a strain on conductor before cutting conductor an inch from where it enters dead-ending device.	II.B.4.b. Cutting wire at this point is required in order to eliminate kinked portion after dead-ending device.	II.B.4.b. The two outside conductors will be removed first before removing the inside conductors.
(1) Lower conductor to the ground.	II.B.4.b.(1) Use handline on wire grip when lowering conductor.	
c. Lineman: Ascend corner pole and remove other end of primary conductors and lower to ground.		
(1) Coil conductors in a continuous coil using pressure splicing devices.	II.B.4.c.(1) Splice ends together with crimp-on connectors.	
5. Remove lightning arresters, pin insulators, fused cutouts and dead-end clevis assemblies at the transformer pole.		
a. Lineman: Remove lightning arresters from their L-brackets and lower to the ground. Remove L-brackets.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Remove pin insulators, fused cutouts and dead-end assemblies.	II.B.5.a.(1) Lower all porcelain items very carefully.	
(2) Stow gear as directed.		
6. Remove transformers (secondary distribution).		
a. Groundman: Raise pole-top gin to lineman.		
b. Lineman #2: Ascend pole and assist lineman #1 in securing pole-top gin to top of pole.		
c. Groundman: Raise block and tackle, wire sling and tag line to lineman.		
d. Linemen #1 and #2: Secure block and tackle to pole-top gin with fall line coming from top block.		
(1) Secure wire sling to center transformer and attach block and tackle to wire sling.		
(2) Attach tag line to transformer using a timber hitch.		
e. Ground crew: Take a strain on the block and tackle fall line until transformer hanger clears the supporting crossarm.		
(1) Lower transformer to the ground.	II.B.6.e.(1) Crew member will steady transformer descent with tag line. Move transformer away from base of pole before lowering #2 and #3.	

(2) Repeat steps of procedure on the two remaining transformers.

(3) Store transformers as directed by instructor.

7. Remove remaining primary conductors.

a. Lineman: Ascend corner pole (next pole in line after transformer pole) with handline.

(1) Secure handline above the top crossarm.

b. Groundman: Hoist lineman's tools and wire grips.

c. Lineman: Remove the wires from all line pin insulators.

(1) Attach wire grip on outside conductor.

(2) Attach clip of handline to wire grip.

(3) Take a strain on wire grip before cutting conductor at the automatic dead-end device.

II.B.7.c.(3) If conductor is cut while there is slack on the line, the next pole in line will vibrate back and forth causing possible hazard to a lineman on that pole.

d. Groundman: Lower conductor to the ground.

e. Lineman: Remove remaining conductors as per II.B.7.a. thru II.B.7.c.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(1) Remove all associated hardware.		
(2) Repeat procedures for removing primary conductors on remaining poles.		
f. Groundman: Splice conductors together and roll into 2 coils.	II.B.7.f. Conductors will be rolled up on two reels supported on a reel holder.	
8. Remove guys and guying hardware.		
a. Lineman: Ascend guyed pole with handline.		
(1) Secure handline above top crossarm.		
b. Groundman: Hoist lineman's tools and wire grip.		
c. Lineman: Attach wire grip to guy wire.		
(1) Attach clip of handline on wire grip.		
d. Groundman: Take a strain on the handline.		
e. Lineman: Remove thru-bolt holding guy attachment to the pole.		
f. Groundman: Lower guy assembly to the ground.	II.B.8.f. Stress: Avoid kinking of the guy wire.	
(1) Remove preformed guy grips from guy assembly.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(2) Remove strand vise from anchor rod.

(3) Roll guy strands into a coil and identify with a tag stating assigned pole.

(4) Store hardware and guy strands as directed by instructor.

9. Remove hardware and crossarms.

a. Lineman: Ascend pole with handline.

(1) Secure handline above top crossarm.

b. Groundman: Hoist lineman's tool kit.

c. Linemen #1 and #2: Remove dead-end clevis assemblies, pin insulators and carefully lower items to the ground.

(1) Secure handline to crossarm with clove and half hitch.

(a) Lower crossarm to ground.

(2) Remove flat brace lag screws, nuts and washers.

II.B.9.c.(2) On double arm, allow thru-bolt to support one crossarm while opposite crossarm is lowered to the ground.

d. Groundman: Store all line material as directed by the instructor.

OUTLINE OF INSTRUCTION

e. Lineman: Remove handline before descending pole.

(1) Make up handline and store in a hanging position.

III. Practical application.

A. Disassembly of pole line and storage of equipment and materials shall be done in accordance with Job Sheet CE "A" JS 2.1.13.1, "Disassembly Pole Line".

IV. Summary:

A. Job Sheet.

B. Steps of procedure.

C. Practical application.

D. Questions.

V. Test: None.

INSTRUCTOR ACTIVITY

II.B.9.c. All steps of procedure shall be executed 100% correct.

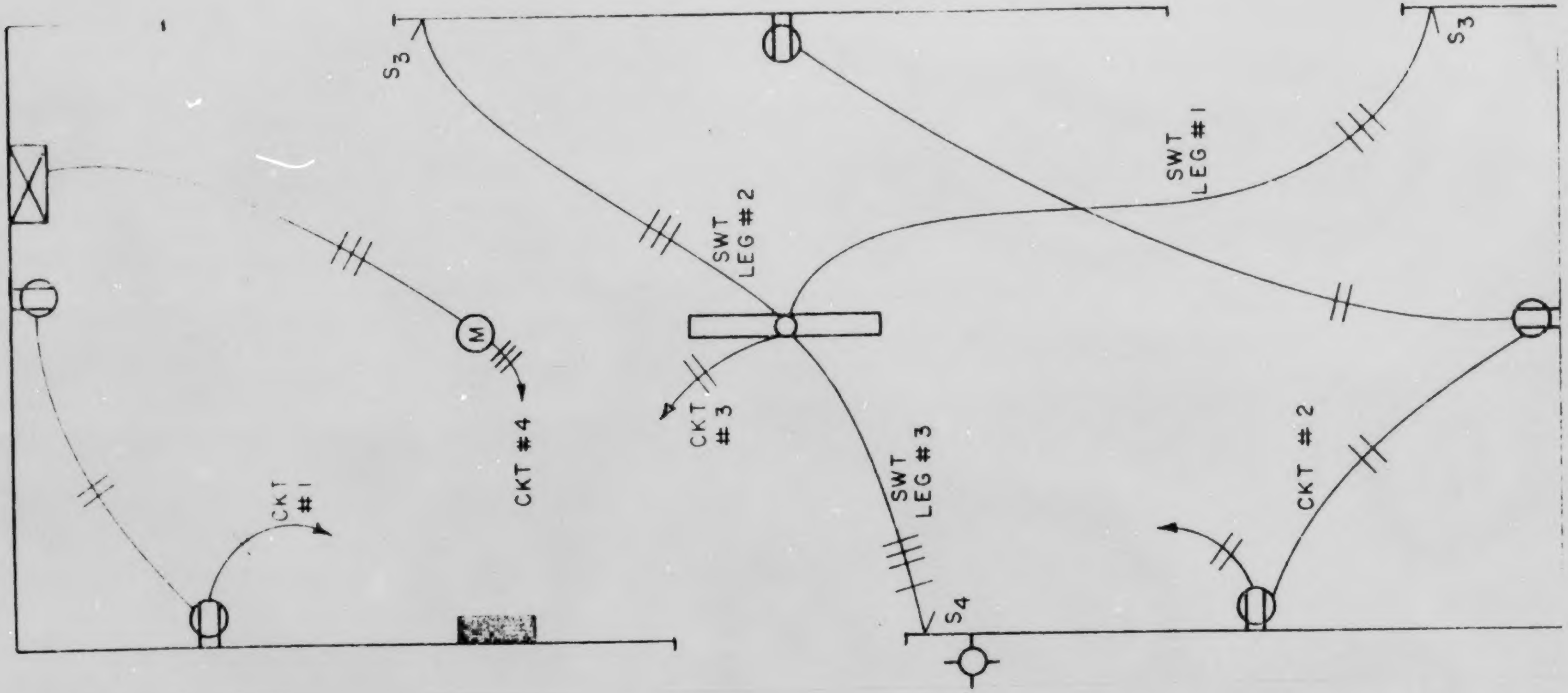
STUDENT ACTIVITY

MODIFICATIONS

Instructor Guide 22.1 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

CONSTRUCTION ELECTRICIAN'S SCHOOL
CEA 1.3.12.Dwg.1
"Cubicle Wiring"
Room #1

3-16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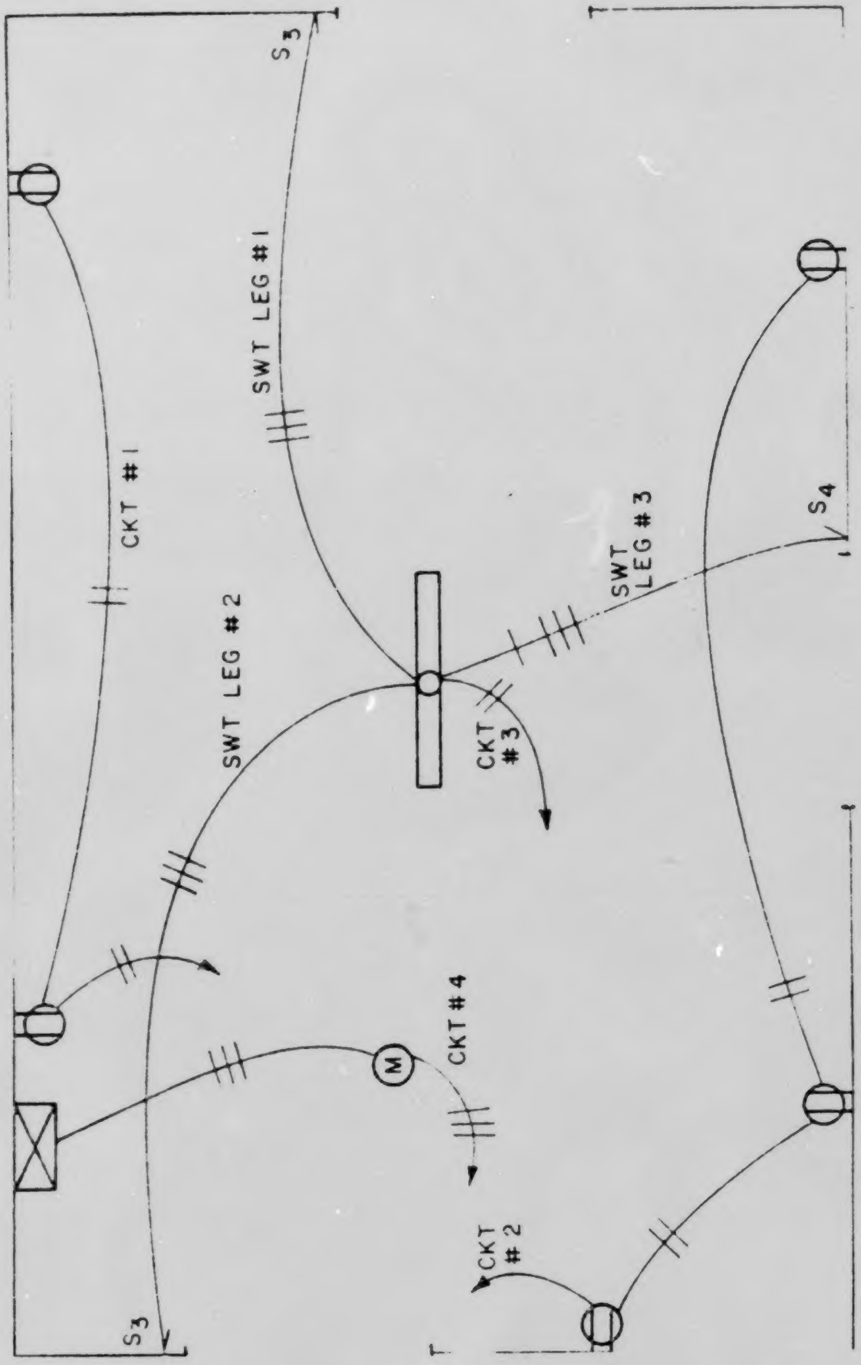
CONSTRUCTION ELECTRICAN'S SCHOOL
CEA 1.3.12.Dwg.1
"Cubilcle Wiring"
Room #2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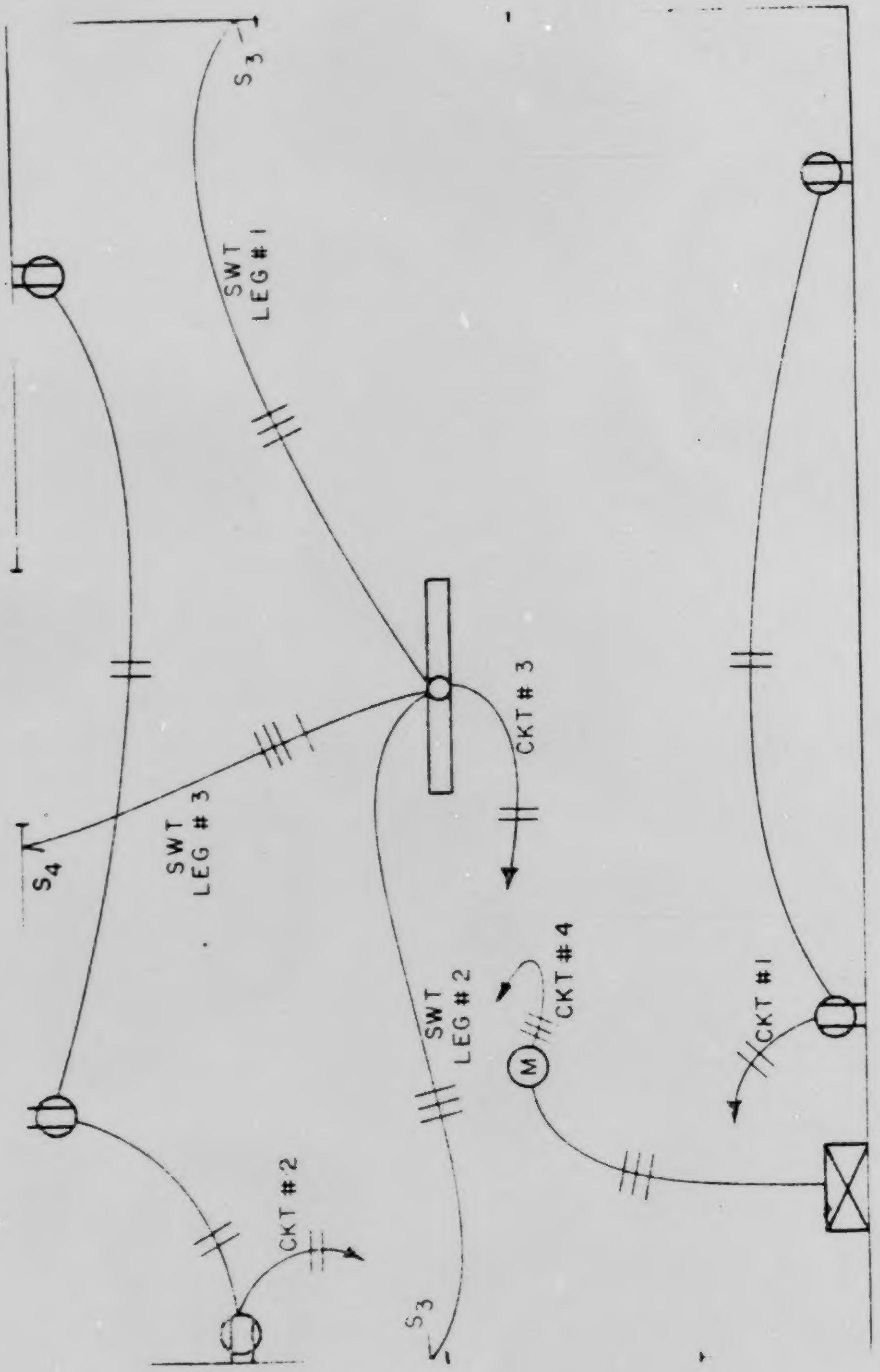
CONSTRUCTION ELECTRICAN'S SCHOOL
CEA 1.3.12.Dwg.1
"Cubicle Wiring"
Room #3

316



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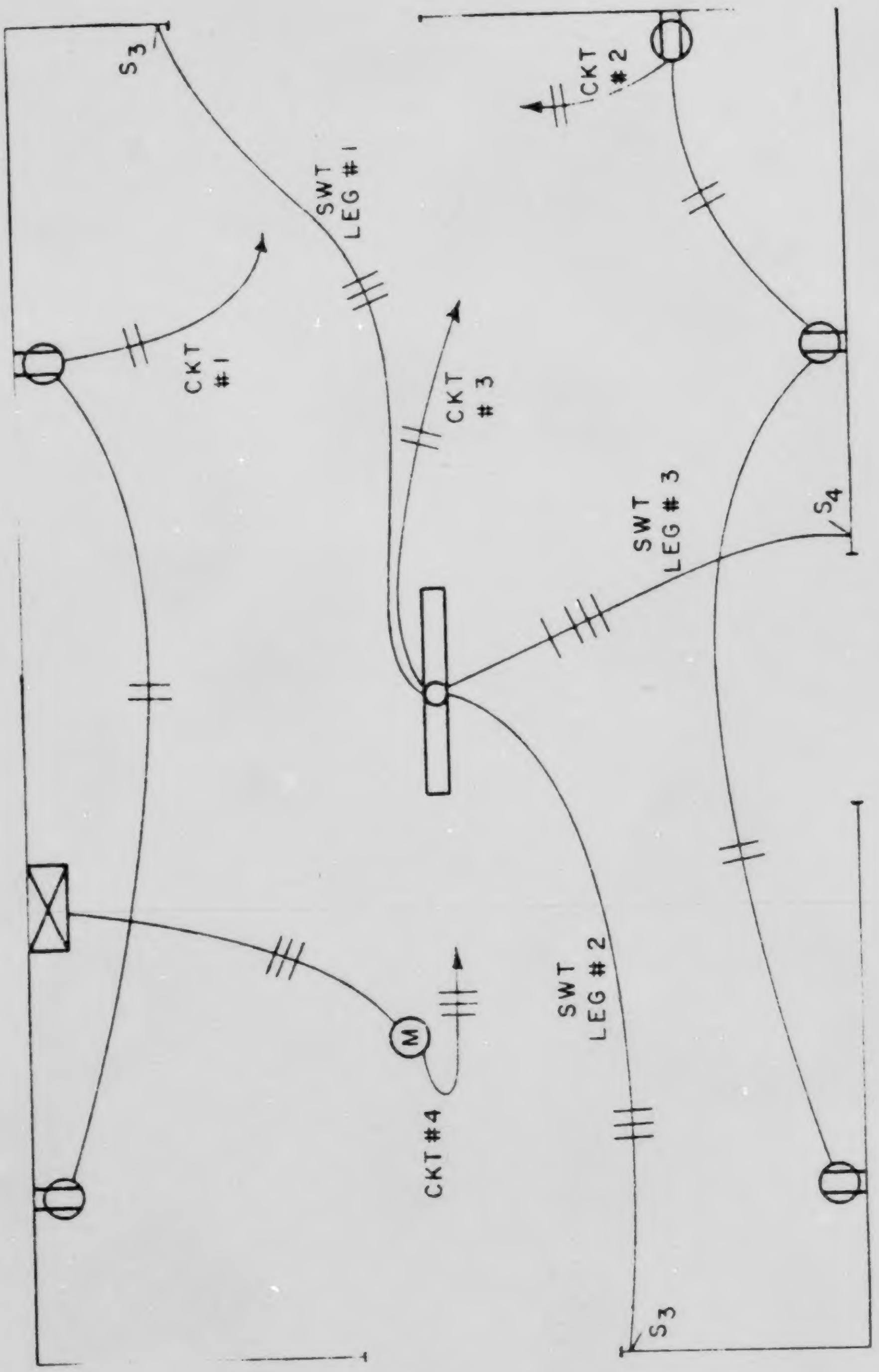
CONSTRUCTION ELECTRICIAN'S SCHOOL
CEA 1.3.12.Dwg.1
"Cubicle Wiring"
Room #4

317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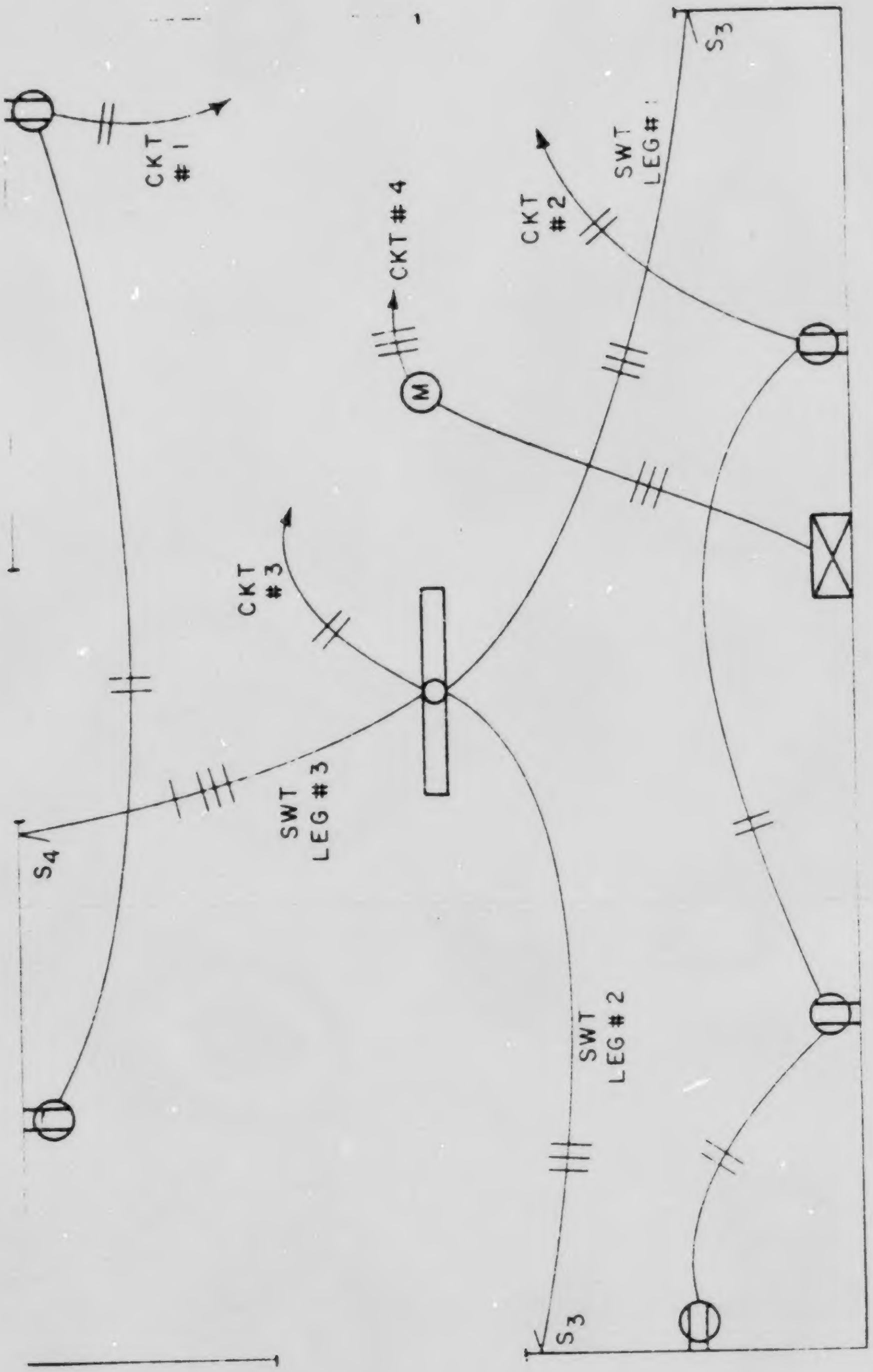
CONSTRUCTION ELECTRICIAN'S SCHOOL
CEA 1.3.12.Dwg.1
"Cubicle Wiring"
Room #5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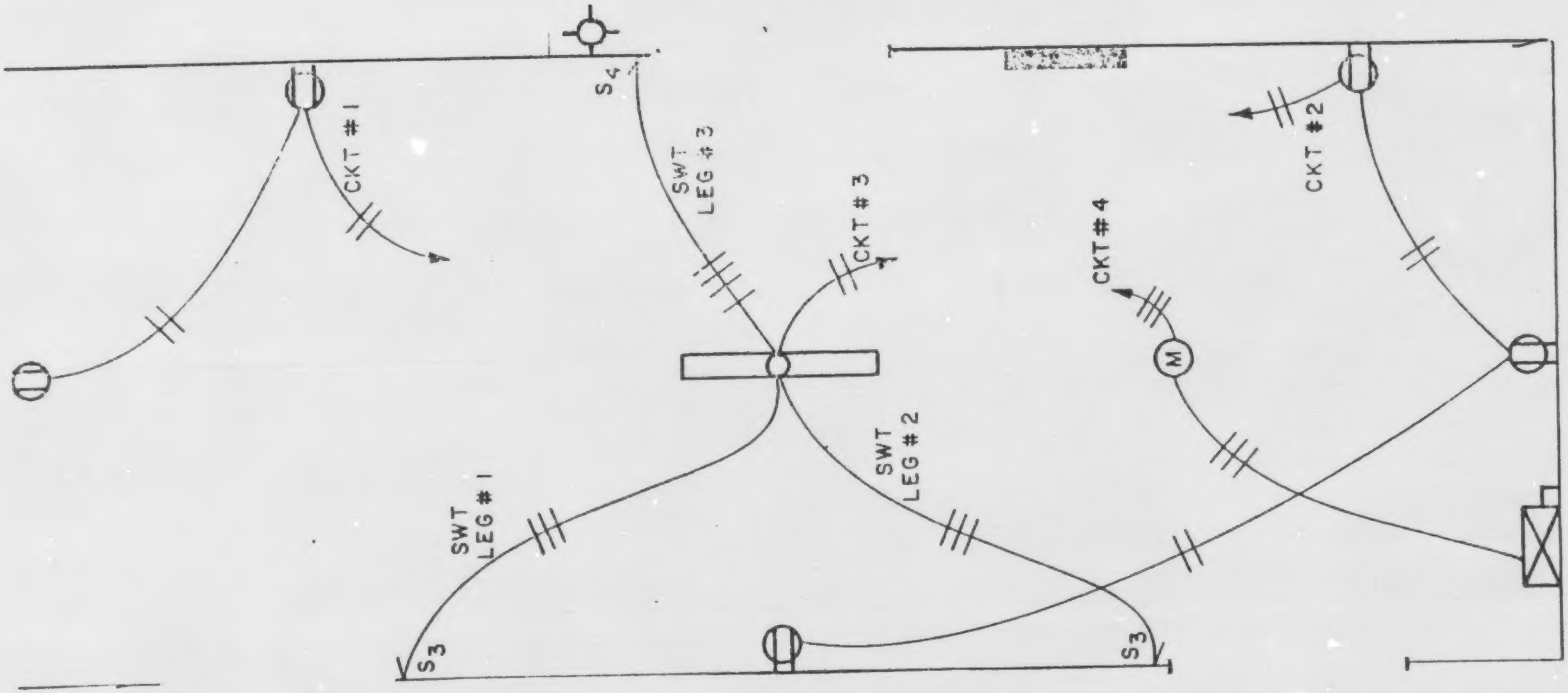
CONSTRUCTION ELECTRICIAN'S SCHOOL
CEA 1.3.12 Dwg. 1
"Cubicle Wiring"
Room #6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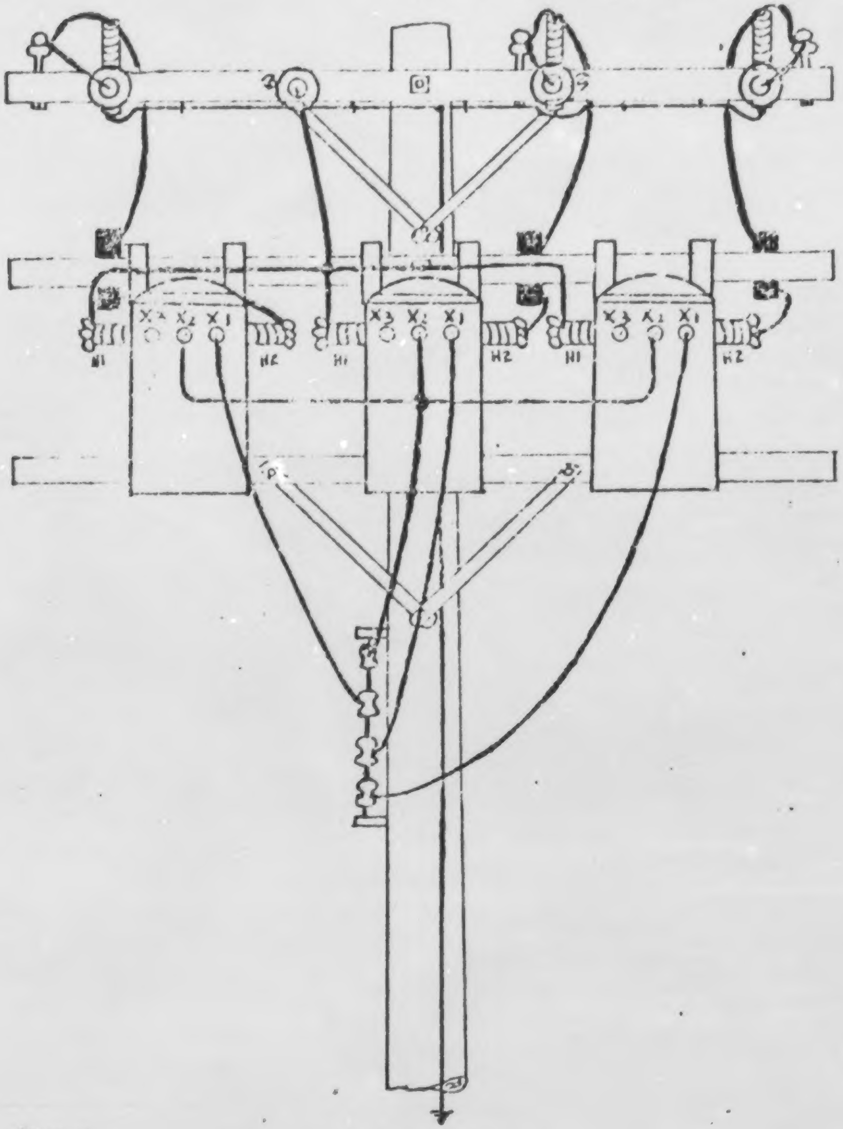
CE "A" DWG .1.9.1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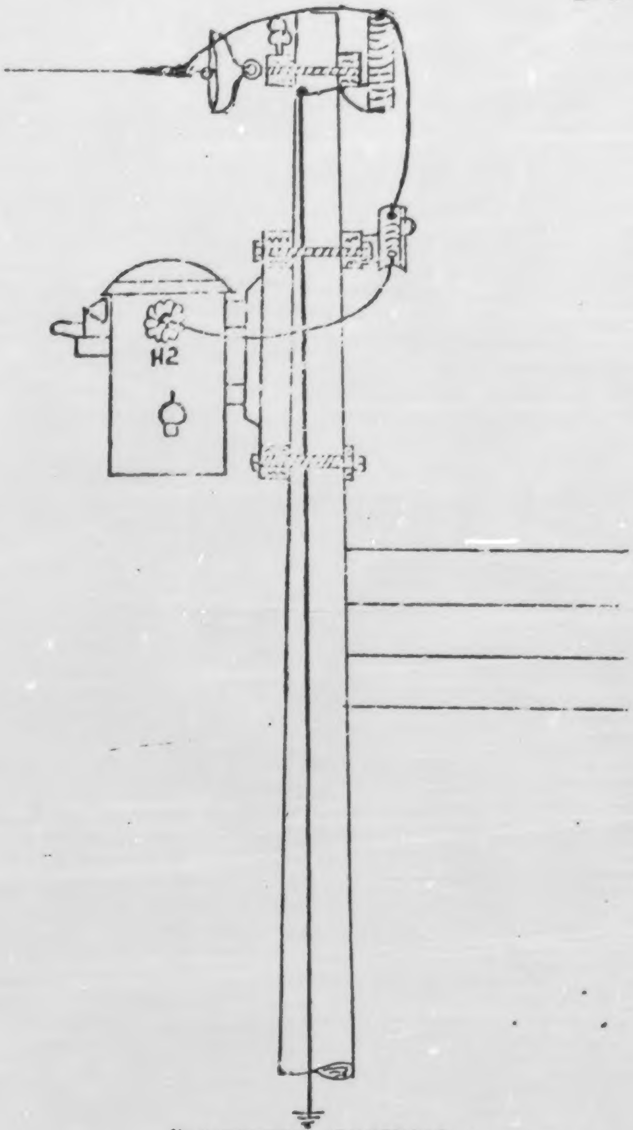
"PRIMARY AND SECONDARY DISTRIBUTION JUMPER CONNECTIONS"

(1 of 1)



"LIGHTNING ARRESTERS, FUSE CUTOUTS, AND TRANSFORMER CONNECTIONS"

590

MODIFICATIONS

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of this publication could not be reproduced in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education."

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NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 1.3.1.IS.1
CLASS: 6

TITLE: BOXES, FITTINGS AND ELECTRICAL DEVICES

INTRODUCTION: This information sheet will guide you in identifying the various boxes, fittings and electrical devices used in construction.

INSTRUCTION MATERIALS:

A. Publications:

1. Texts:

a. NAVPERS 10636-G, CE 3 & 2, Chapter 7

b. National Electrical Code, Article 370

2. Reference:

a. American Electrician's Handbook, 9th Edition, Croft, Carr and Watt; Mc Graw-Hill Book Co., N. Y., N. Y.

B. Materials:

1. Boxes, steel

2. Boxes, non-metallic

3. Fittings

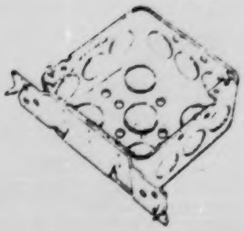
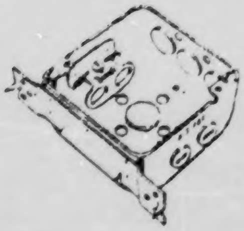
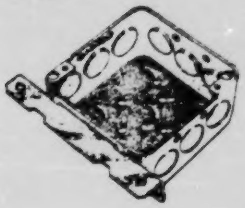
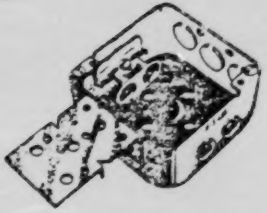
4. Electrical devices

5. Wall plates

C. Instructor Prepared Materials

1. Electrical material display board

4" SQUARE 1½" DEEP

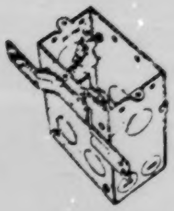
4¹¹/₁₆" SQUARE

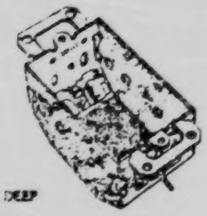
SHALLOW

HANDY BOXES

SWITCH BOXES

SECTIONAL

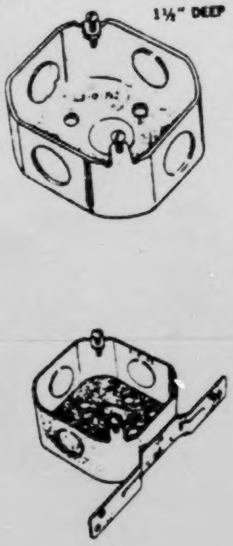




OUTLET BOXES

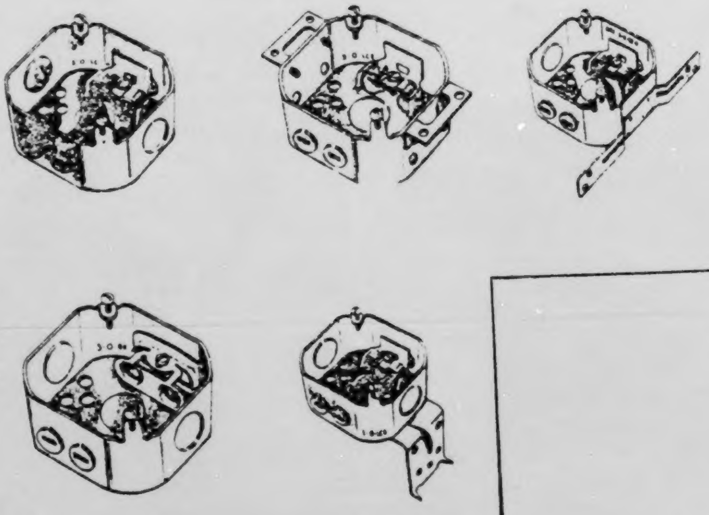
3½" OCTAGON

1¼" DEEP



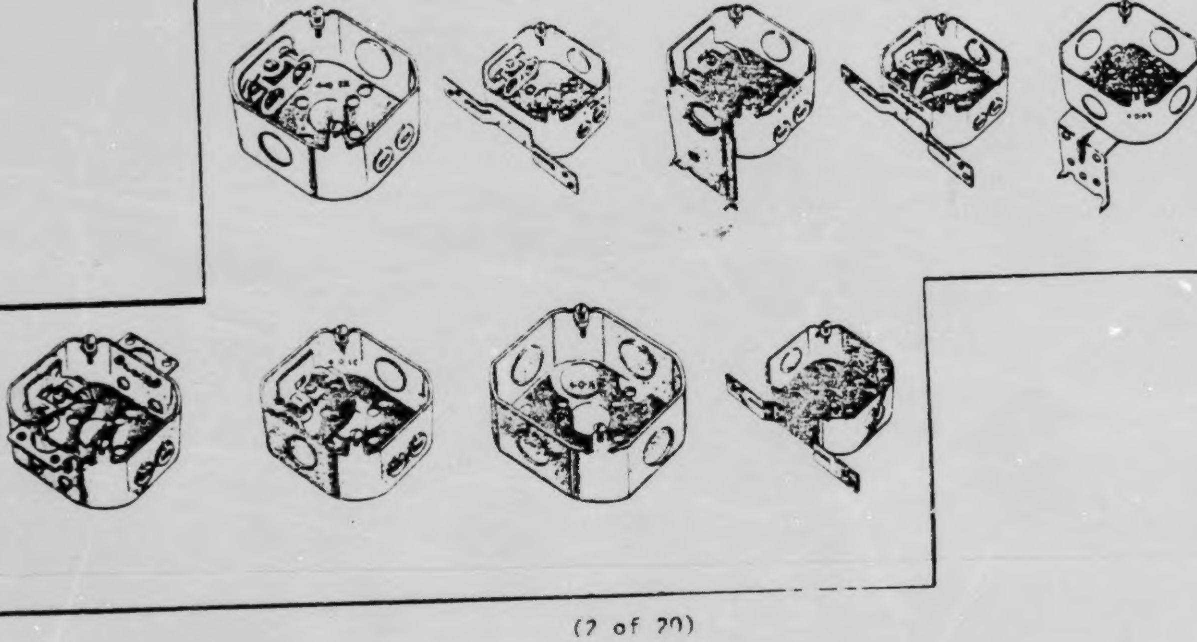
3½" OCTAGON

1½" DEEP



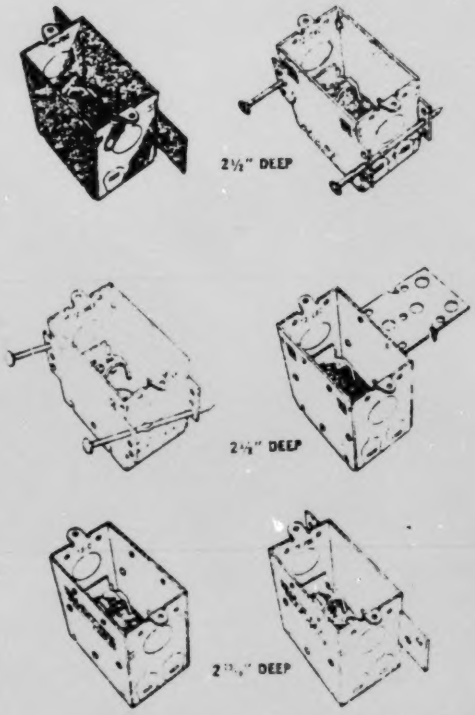
4" OCTAGON

1½" DEEP

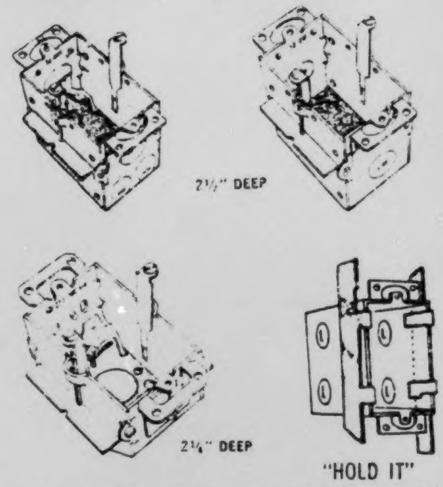


325

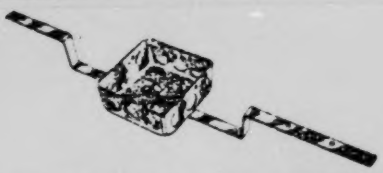
WELDED SWITCH BOXES


2½" DEEP
2½" DEEP
2¹³⁄₁₆" DEEP

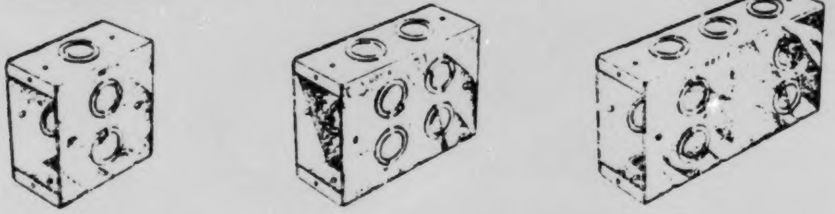
OLD WORK BOX


2½" DEEP
2¼" DEEP
"HOLD IT"

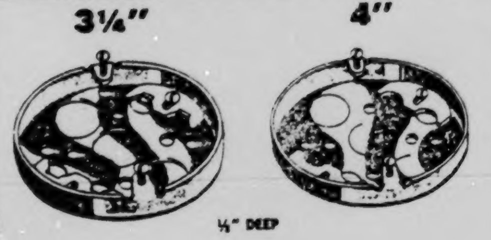
HANGER ASSEMBLIES



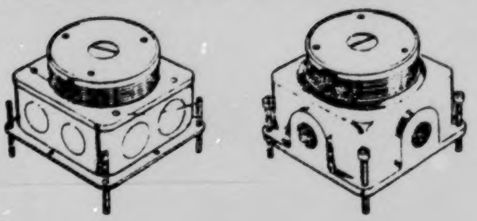
MASONRY THRU BOXES



PANCAKE BOXES

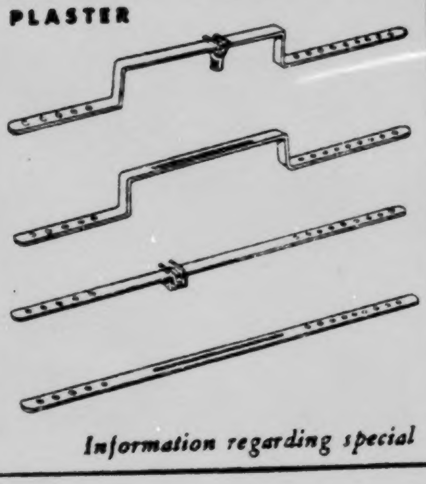


FLOOR BOXES

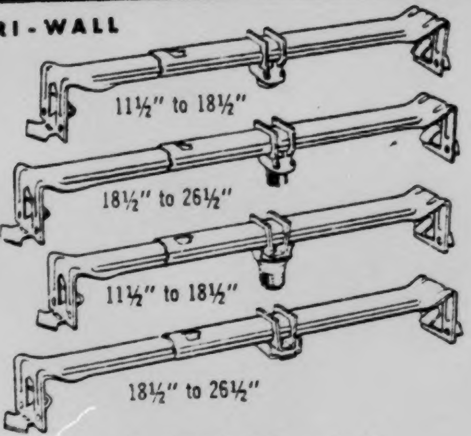


BOX HANGERS

PLASTER

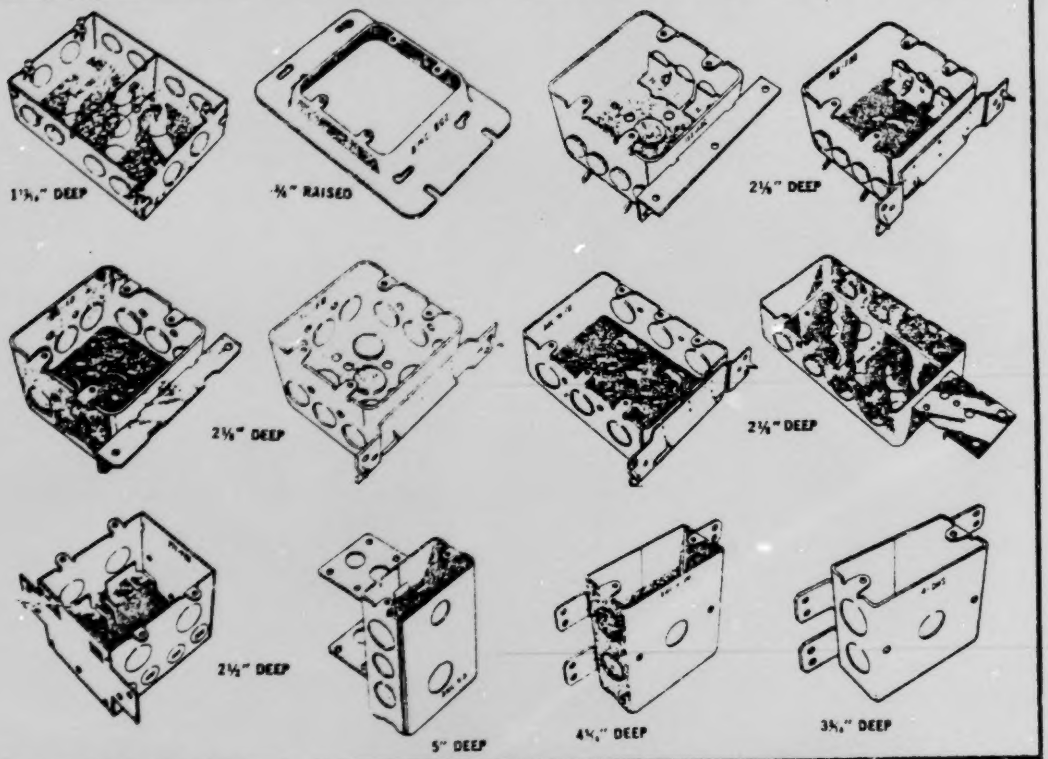


DRI-WALL

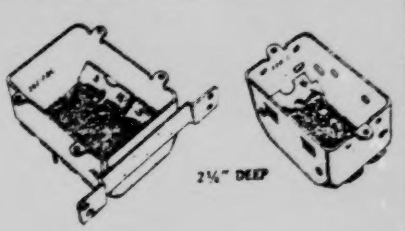

11½" to 18½"
18½" to 26½"
11½" to 18½"
18½" to 26½"

Information regarding special lengths and offsets furnished upon request.

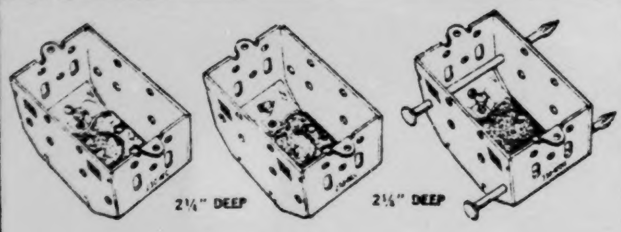
GANG BOXES and SWITCH RINGS


1 13/16" DEEP
½" RAISED
2⅛" DEEP
2⅛" DEEP
2⅛" DEEP
2½" DEEP
5" DEEP
4 11/16" DEEP
3 5/16" DEEP

SOLID DRAWN

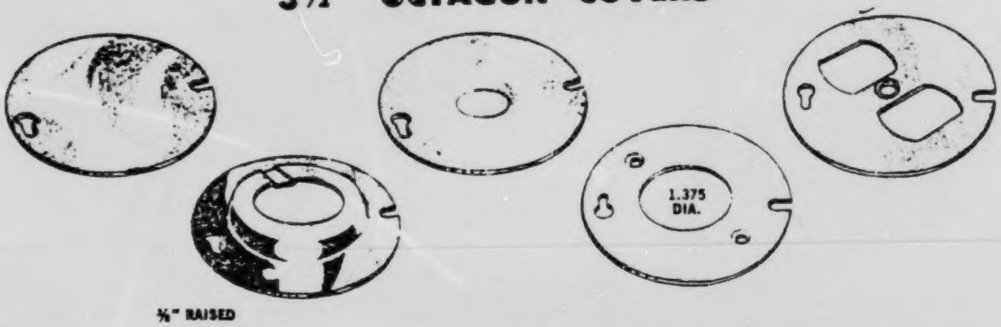


WELDED

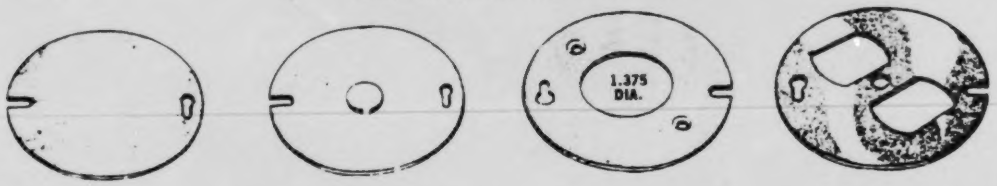

2¼" DEEP
2½" DEEP

OCTAGON RINGS COVERS

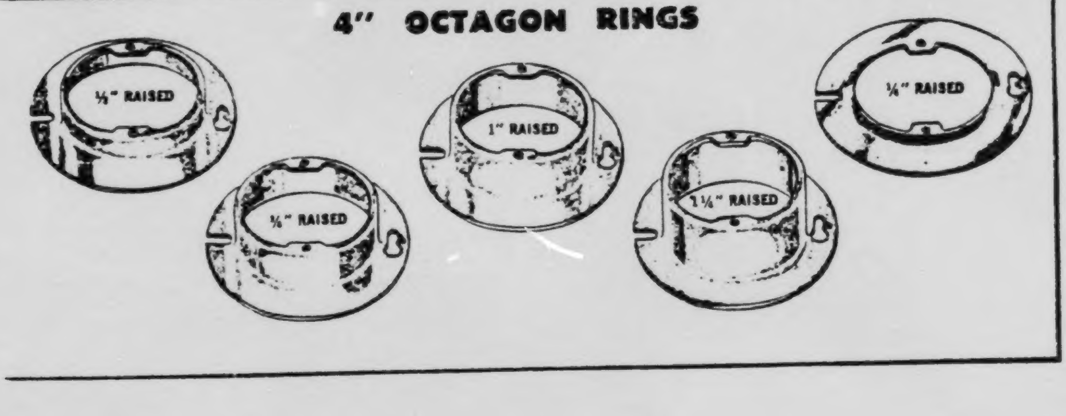
3½" OCTAGON COVERS


1.375 DIA.
⅝" RAISED

4" OCTAGON COVERS

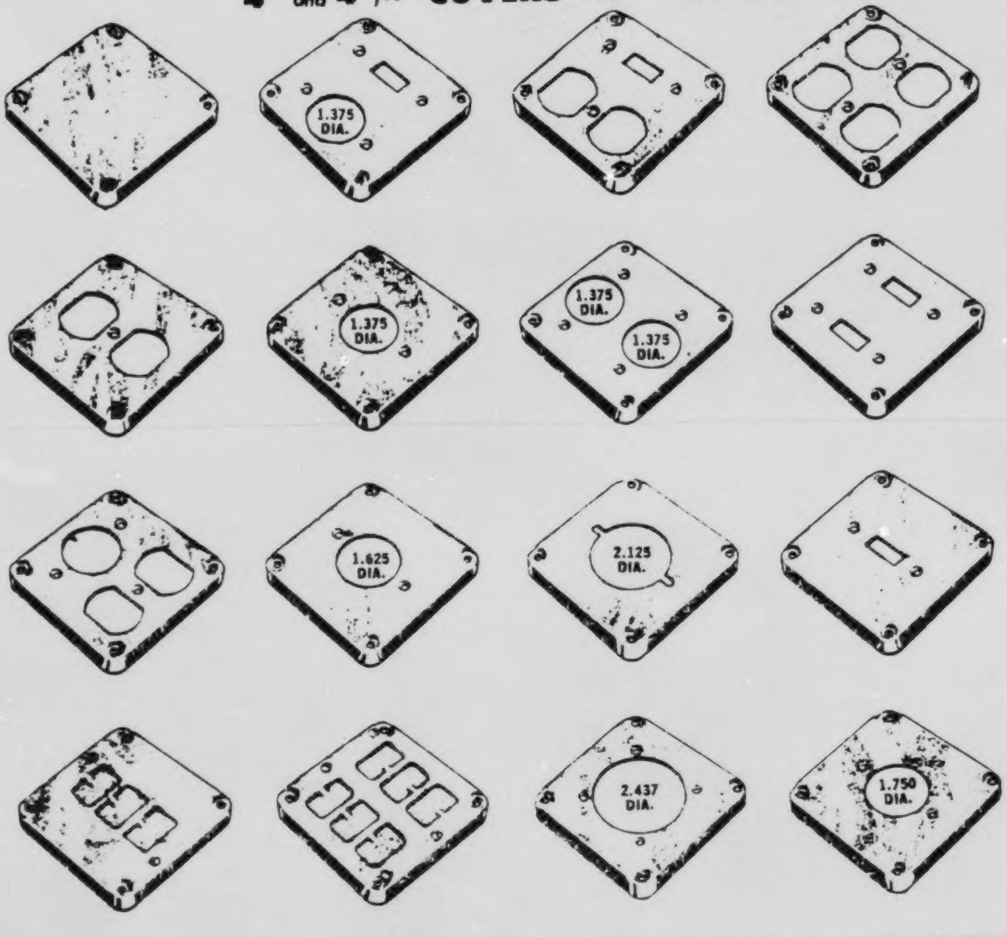


4" OCTAGON RINGS


½" RAISED
⅝" RAISED
1" RAISED
1¼" RAISED
¼" RAISED

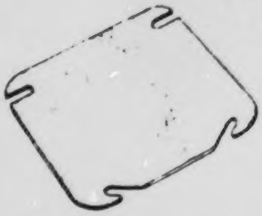
SQUARE SURFACE COVERS

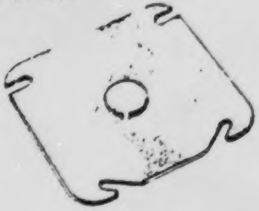
4'' and 4 11/16" COVERS 1/2'' RAISED


1.375 DIA.
1.375 DIA.
1.375 DIA.
1.375 DIA.
1.625 DIA.
2.125 DIA.
2.437 DIA.
1.750 DIA.

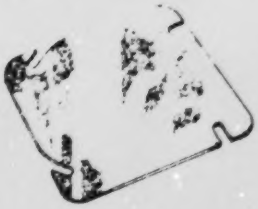
SQUARE RINGS AND COVERS

4" COVERS

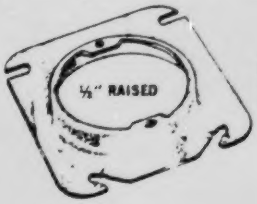


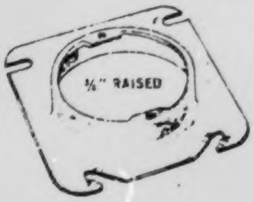


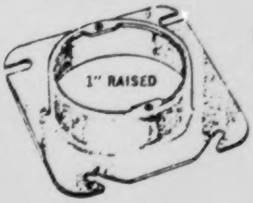
4 11/16" COVERS

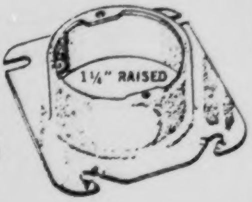


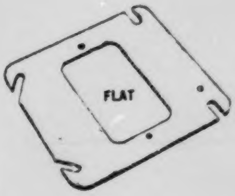
4" SQUARE RINGS

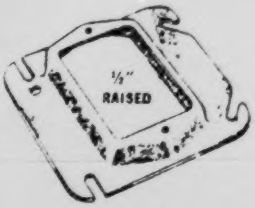


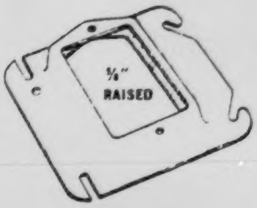


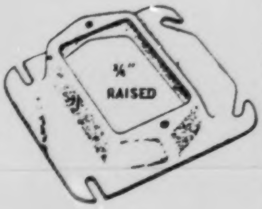


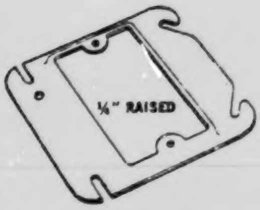


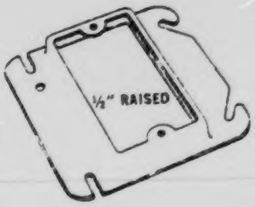


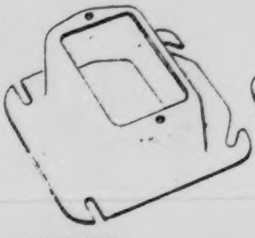


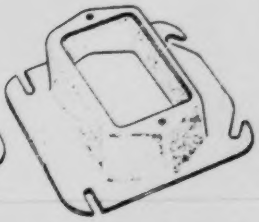




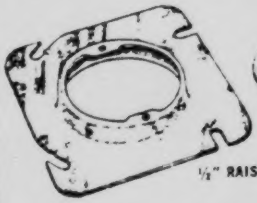


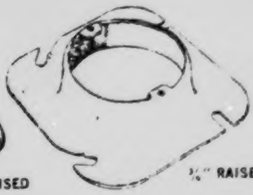


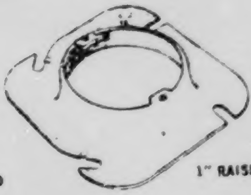


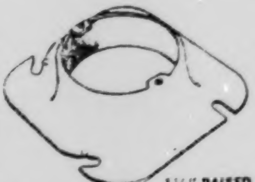


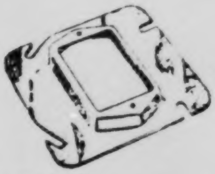
4 11/16" SQUARE RINGS

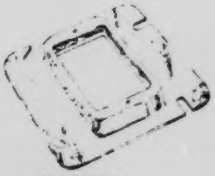


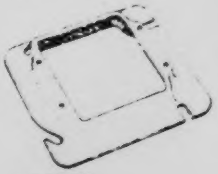


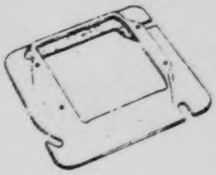






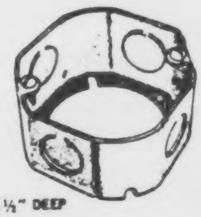






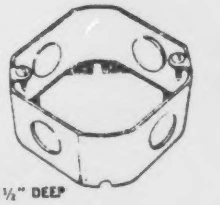
EXTENSION RINGS

3½" OCTAGON



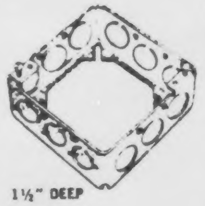
1½" DEEP

4" OCTAGON



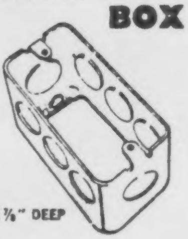
1½" DEEP

4" SQUARE



1½" DEEP

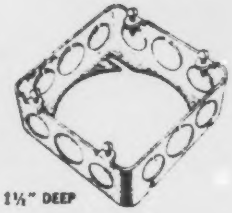
HANDY BOX



1⅞" DEEP

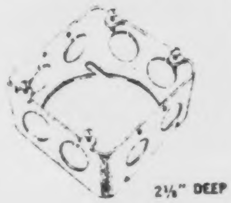
4$^{11}/_{16}$" SQUARE

SHALLOW



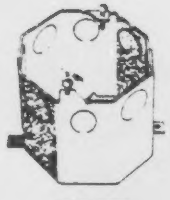
1½" DEEP

DEEP

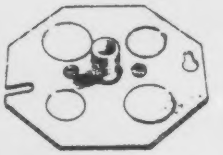


2⅛" DEEP

CONCRETE RINGS & PLATE

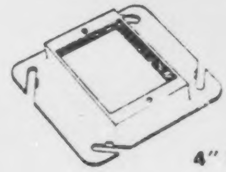


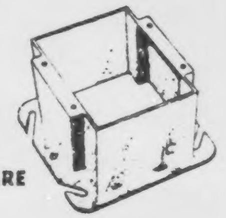
3½" DEEP



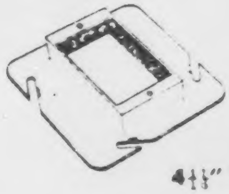
TILE RINGS

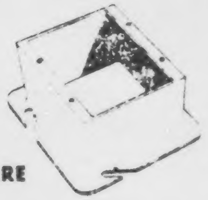
½" THRU 2"
RAISED





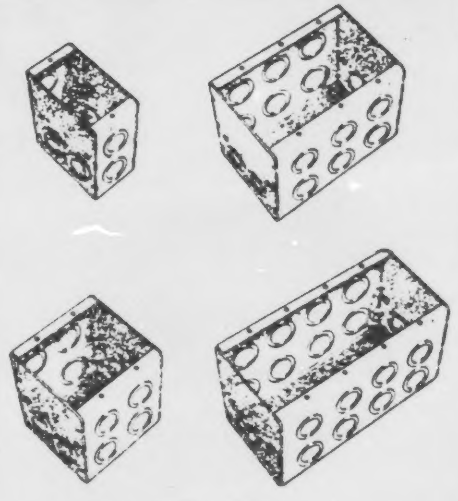
4" SQUARE





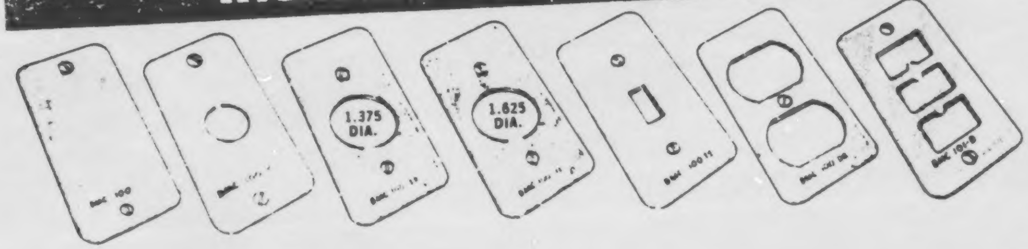
4$^{11}/_{16}$" SQUARE

MASONRY BOXES



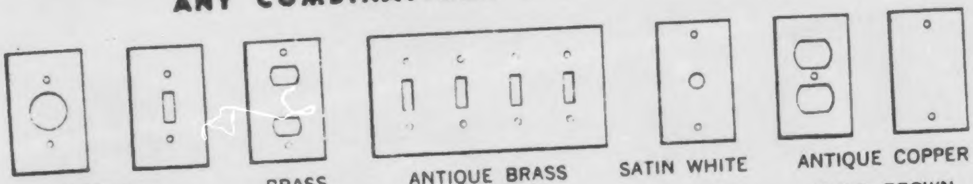
1 THRU 4 GANG
MB – SERIES – 3½" DEEP
MBS – SERIES – 2½" DEEP

HANDY BOX COVERS



DECORATIVE METAL WALL PLATES

ANY COMBINATIONS 1 THRU 10 GANG



CHROME
STAINLESS STEEL

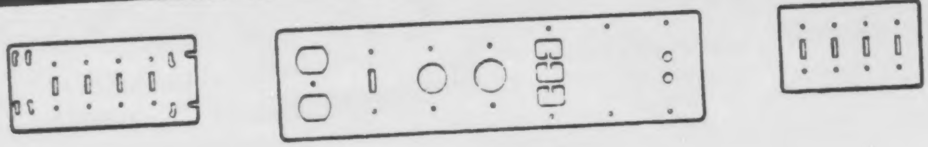
BRASS
COPPER

ANTIQUE BRASS
IVORY GLOSS

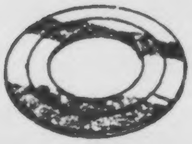
SATIN WHITE
SATIN IVORY

ANTIQUE COPPER
SATIN BROWN

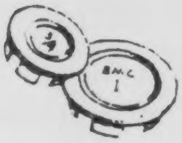
GANG PLATES



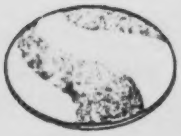
ANY COMBINATION



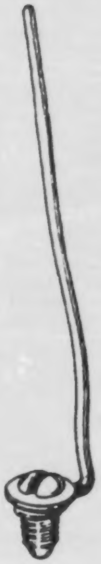
REDUCING
WASHERS



SNAP-IN
SEALS

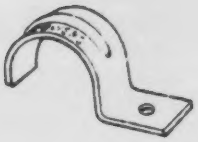


GALVANIZED
CONDUIT
SEALS

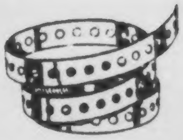


GROUNDING
SCREW WITH
BARE & INSULATED
PIGTAIL

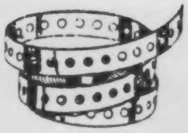
PIPE
STRAP



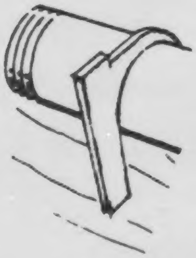
½" THRU 2"



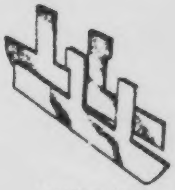
COPPER
GROUND
STRAP



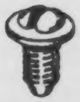
PLUMBERS
PERFORATED
TAPE



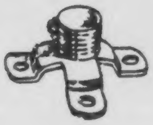
HOLD-FAST
PIPE NAILER
EMT & RIDGED



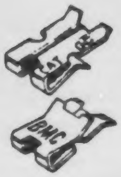
"HOLD IT"
SWITCH BOX
SUPPORT



GROUNDING
SCREW

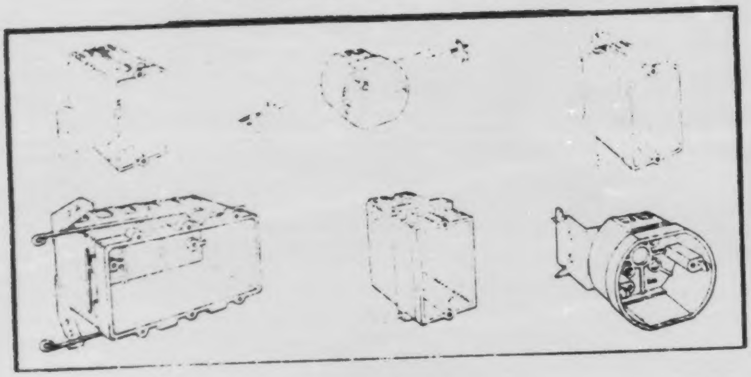


FIXTURE
STUD

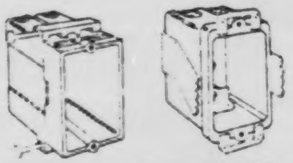


GROUNDING
CLIP

NON-METALLIC BOXES



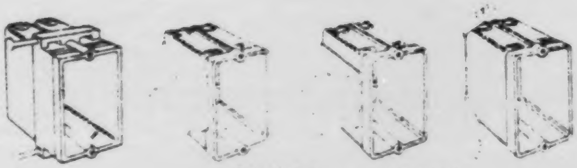
SWITCH BOXES



with Switch Box Support

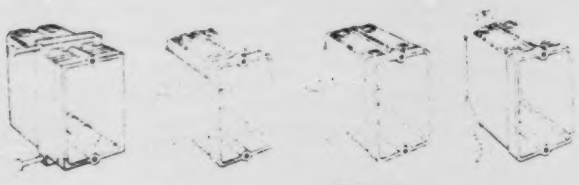
3½" x 2¼"
2-9/16" DEEP

3-9/32" x 2-3/16" x 2½" DEEP



Bkt setback ½ Bkt setback ½

3½" x 2¼"
2⅞" DEEP



Bkt setback ½

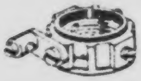
3½" x 2¼"
3⅛" DEEP

ELECTRICAL FITTINGS

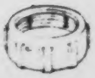
RIGID CONDUIT

MALLEABLE IRON BUSHING:

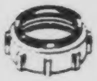
INSULATED THROAT
GROUND BUSHING
WITH GROUND LUGS



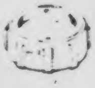
BUSHINGS



INSULATED THROAT BUSHING

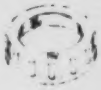


CAPPED BUSHINGS
soft tin cap



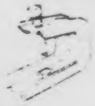
INSULATING BUSHINGS

BRIGHT YELLOW
cellulose propionate

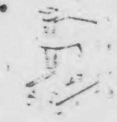


BEAM CLAMPS

stamped steel

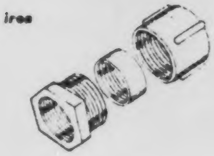


malleable iron



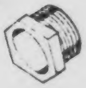
THREE PIECE COUPLINGS

malleable iron

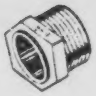


CONDUIT NIPPLES

malleable iron

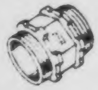


INSULATED THROAT



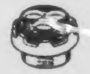
SPACING CONNECTOR

pressure cast



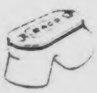
PIPE END FITTING

malleable iron

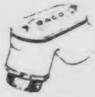


HANDY ELLS

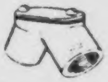
female to female
aluminum



female to male
aluminum

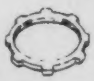


female to female
pressure cast

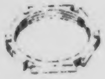


LOCKNUTS

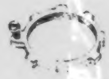
steel



malleable iron

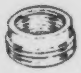


GROUNDING LOCKNUTS
malleable iron

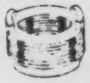


REDUCING BUSHINGS

SMALL
steel, cast iron

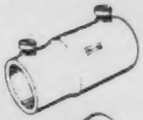


LARGE
cast iron

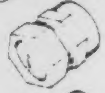


COMBINATION COUPLINGS

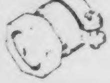
RIGID TO E.M.T. SET SCREW
steel



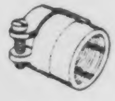
RIGID TO E.M.T. THREADED/ COMPRESSION
malleable iron



FLEXIBLE TO E.M.T.
malleable iron

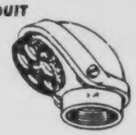


RIGID TO FLEXIBLE
malleable iron

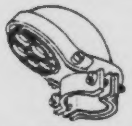


ENTRANCE CAPS

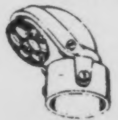
FOR RIGID CONDUIT
malleable iron



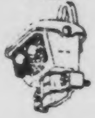
CLAMP TYPE
aluminum
for E.M.T. or rigid conduit



COMBINATION
aluminum

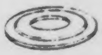


OVAL CABLE
malleable iron



REDUCING WASHERS

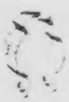
stamped steel
size stamped
on each piece



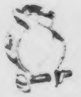
CONDUIT CLAMPS

size stamped on each piece

stamped steel



WITH BOLTS
stamped steel

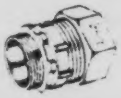


E.M.T. (Thinwall)

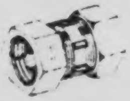
NO THREAD COMPRESSION

rain tight, concrete tight
malleable iron

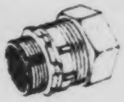
CONNECTORS



COUPLINGS



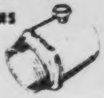
INSULATED THROAT CONNECTORS



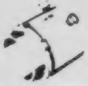
SET SCREW

steel concrete tight

CONNECTORS

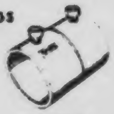


No. 3003-06

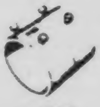


No. 3000-16

COUPLINGS

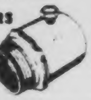


No. 3023-36

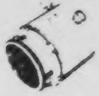


No. 3020-16

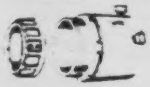
INSULATED THROAT CONNECTORS



No. 3102-3106



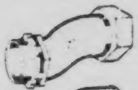
No. 3106



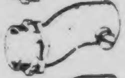
OFFSET CONNECTORS

pressure cast

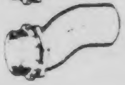
COMPRESSION



SET SCREW



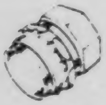
INDENTER



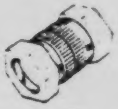
STEEL COMPRESSION

rain tight concrete tight

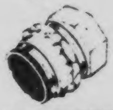
CONNECTORS



COUPLINGS



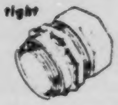
INSULATED THROAT CONNECTORS



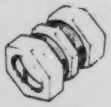
PRESSURE CAST COMPRESSION

rain tight concrete tight

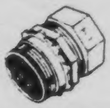
CONNECTORS



COUPLINGS

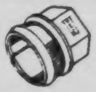


INSULATED THROAT CONNECTORS



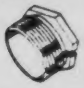
TWO-PIECE CONNECTORS

pressure cast



SPLIT ADAPTERS

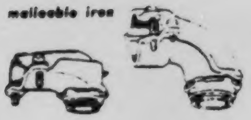
steel



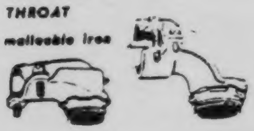
**FOR ARMORED BUSHED CABLE
FLEXIBLE METALLIC TUBING
AND NON-METALLIC CABLE**

90° SQUEEZE CONNECTORS

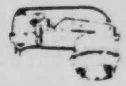
malleable iron



INSULATED THROAT
malleable iron

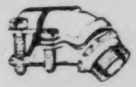


pressure cast



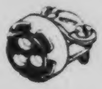
45° SQUEEZE CONNECTORS

malleable iron



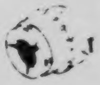
CABLE END FITTING

malleable iron

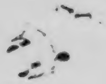


SET SCREW CONNECTORS

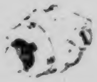
malleable iron



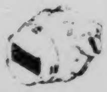
DUPLEX
malleable iron



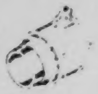
pressure cast



pressure cast

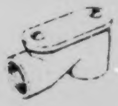


FLEXIBLE METALLIC CONDUIT
pressure cast



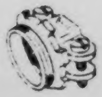
ENTRANCE ELLS

pressure cast
aluminum

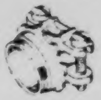


CABLE CONNECTORS

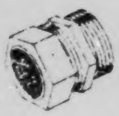
OVAL CABLE
pressure cast



OVAL OR ROUND CABLE
with reversible clamp
pressure cast

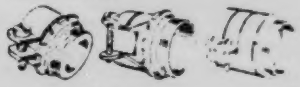


OVAL CABLE WATERTIGHT
pressure cast

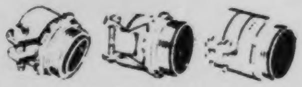


SQUEEZE CONNECTORS

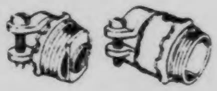
STRAIGHT BOX
malleable iron



STRAIGHT BOX INSULATED THROAT
malleable iron

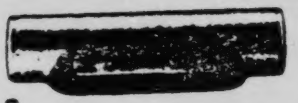


STRAIGHT BOX
pressure cast



338

Conduit Outlet Bodies



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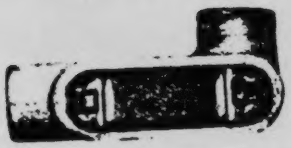

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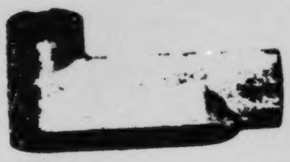
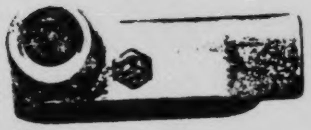
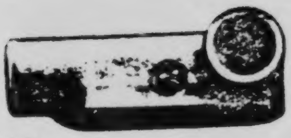


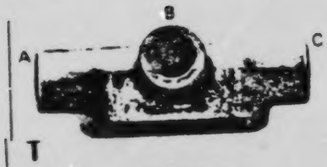
LB



LL



LR



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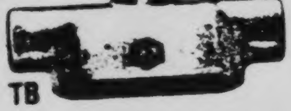


TB

FS and FD Single Gang Boxes

Application:

Cast device boxes are installed to:

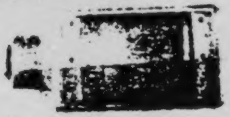
- accommodate wiring devices
- act as pull boxes for conductors in a conduit system
- Available as shallow (FS) or deep (FD) configuration. Use FD if device to be enclosed exceeds 1 5/8" in depth

Standard Materials:

- Feraloy and aluminum

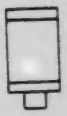
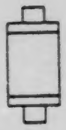
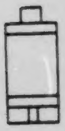
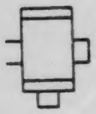
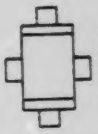
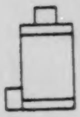
Standard Fihishes:

- Feraloy—cadmium zinc electroplate and aluminum cellulose lacquer
- Aluminum—natural



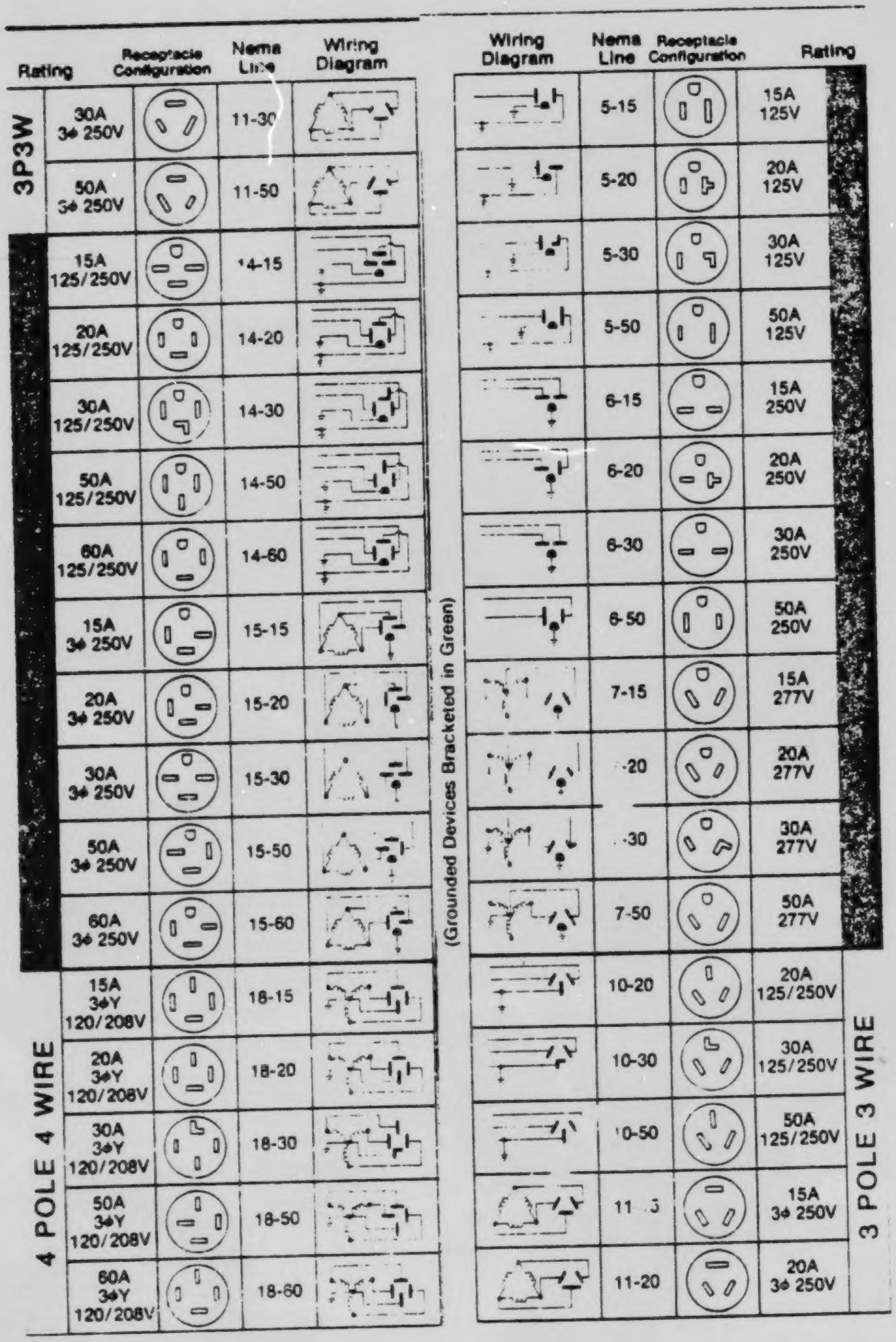
Dead End

Threaded Rigid

	Size	Cat. #
	1/2	FS1
	3/4	FS2
	1	FS3
	1/2	FD1
	3/4	FD2
	1	FD3
	1/2	FSC1
	3/4	FSC2
	1	FSC3
	1/2	FDC1
	3/4	FDC2
	1	FDC3
	1/2	FSCC1
	3/4	FSCC2
	1/2	FDCC1
	3/4	FDCC2
	1/2	FST1
	3/4	FST2
	1/2	FDT1
	3/4	FDT2
	1	FDT3
	1/2	FSX1
	3/4	FSX2
	1/2	FDX1
	3/4	FDX2
	1	FDX3
	1/2	FSL1
	3/4	FSL2
	1/2	FDL1
	3/4	FDL2

LOCKING TYPE
WIRING DEVICES

NEMA Configurations

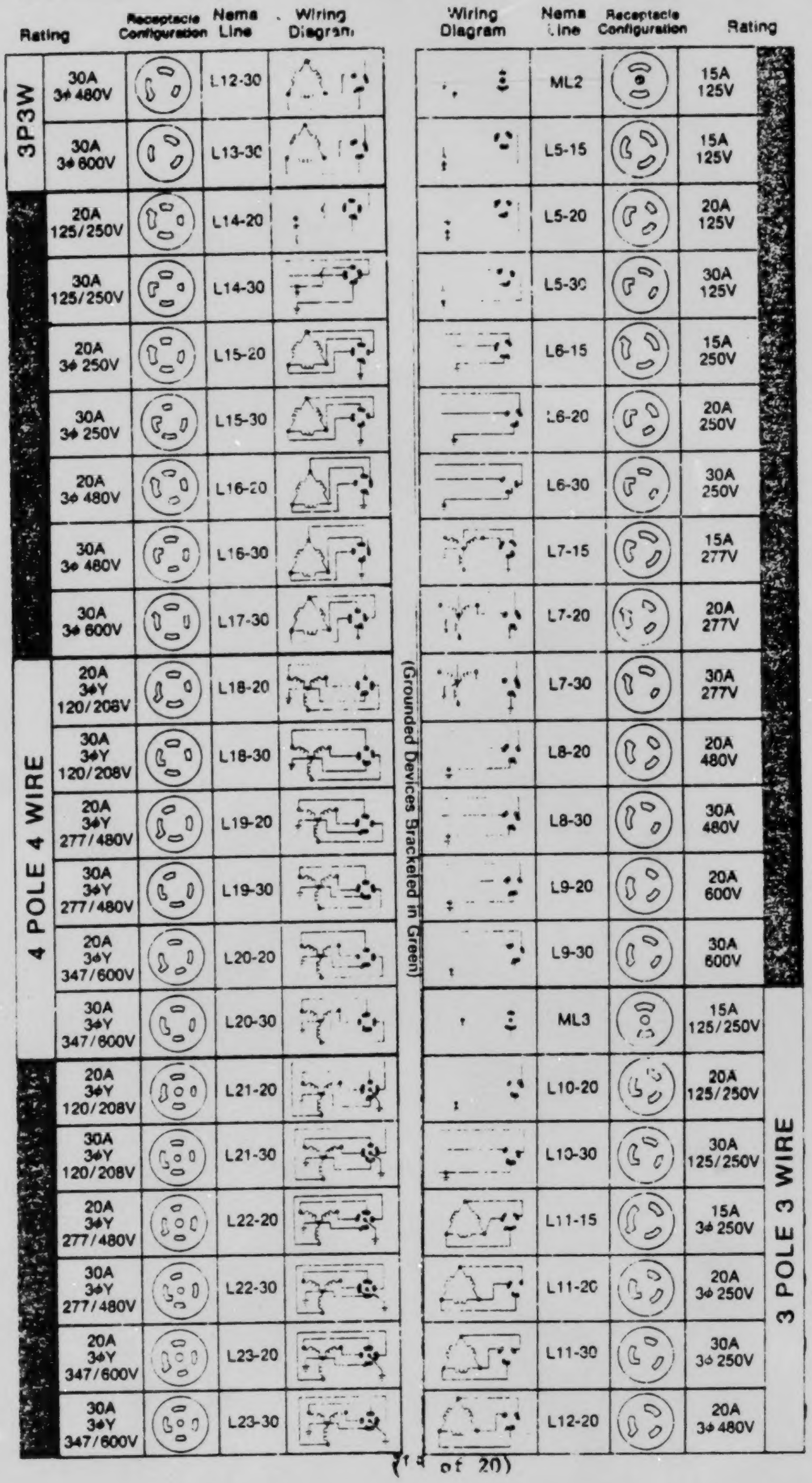


	Rating	Receptacle Configuration	Nema Line	Wiring Diagram
3P3W	30A 3φ 250V		11-30	
	50A 3φ 250V		11-50	
	15A 125/250V		14-15	
	20A 125/250V		14-20	
	30A 125/250V		14-30	
	50A 125/250V		14-50	
	60A 125/250V		14-60	
	15A 3φ 250V		15-15	
	20A 3φ 250V		15-20	
	30A 3φ 250V		15-30	
	50A 3φ 250V		15-50	
	60A 3φ 250V		15-60	
4 POLE 4 WIRE	15A 3φY 120/208V		18-15	
	20A 3φY 120/208V		18-20	
	30A 3φY 120/208V		18-30	
	50A 3φY 120/208V		18-50	
	60A 3φY 120/208V		18-60	

(Grounded Devices Bracketed in Green)

Wiring Diagram	Nema Line	Receptacle Configuration	Rating	
	5-15		15A 125V	
	5-20		20A 125V	
	5-30		30A 125V	
	5-50		50A 125V	
	6-15		15A 250V	
	6-20		20A 250V	
	6-30		30A 250V	
	6-50		50A 250V	
	7-15		15A 277V	
	7-20		20A 277V	
	7-30		30A 277V	
	7-50		50A 277V	
	10-20		20A 125/250V	3 POLE 3 WIRE
	10-30		30A 125/250V	
	10-50		50A 125/250V	
	11-15		15A 3φ 250V	
	11-20		20A 3φ 250V	

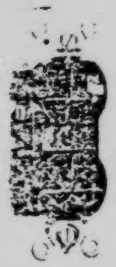
340

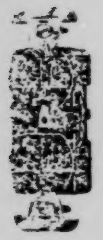


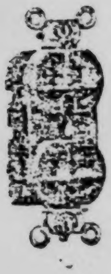
	Rating	Receptacle Configuration	Nema Line	Wiring Diagram	Wiring Diagram	Nema Line	Receptacle Configuration	Rating	
3P3W	30A 3φ 480V		L12-30			ML2		15A 125V	
	30A 3φ 600V		L13-30			L5-15		15A 125V	
	20A 125/250V		L14-20			L5-20		20A 125V	
	30A 125/250V		L14-30			L5-30		30A 125V	
	20A 3φ 250V		L15-20			L6-15		15A 250V	
	30A 3φ 250V		L15-30			L6-20		20A 250V	
	20A 3φ 480V		L16-20			L6-30		30A 250V	
	30A 3φ 480V		L16-30			L7-15		15A 277V	
	30A 3φ 600V		L17-30			L7-20		20A 277V	
4 POLE 4 WIRE	20A 3φY 120/208V		L18-20			L7-30		30A 277V	
	30A 3φY 120/208V		L18-30			L8-20		20A 480V	
	20A 3φY 277/480V		L19-20			L8-30		30A 480V	
	30A 3φY 277/480V		L19-30			L9-20		20A 600V	
	20A 3φY 347/600V		L20-20			L9-30		30A 600V	
	30A 3φY 347/600V		L20-30			ML3		15A 125/250V	3 POLE 3 WIRE
	20A 3φY 120/208V		L21-20			L10-20		20A 125/250V	
	30A 3φY 120/208V		L21-30			L10-30		30A 125/250V	
	20A 3φY 277/480V		L22-20			L11-15		15A 3φ 250V	
	30A 3φY 277/480V		L22-30			L11-20		20A 3φ 250V	
	20A 3φY 347/600V		L23-20			L11-30		30A 3φ 250V	
	30A 3φY 347/600V		L23-30			L12-20		20A 3φ 480V	

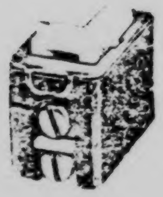
(Grounded Devices Bracketed in Green)

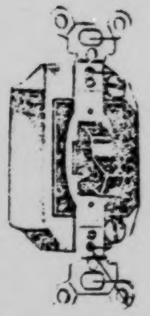
(1[illegible] of 20)

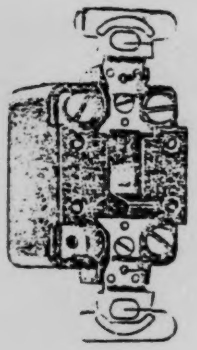


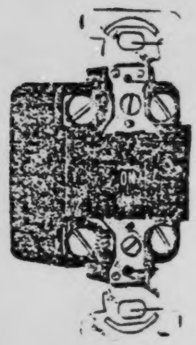


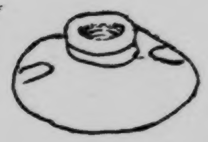


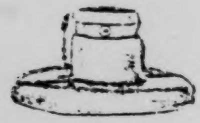


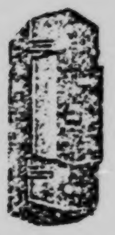


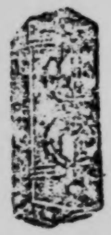


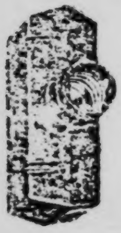


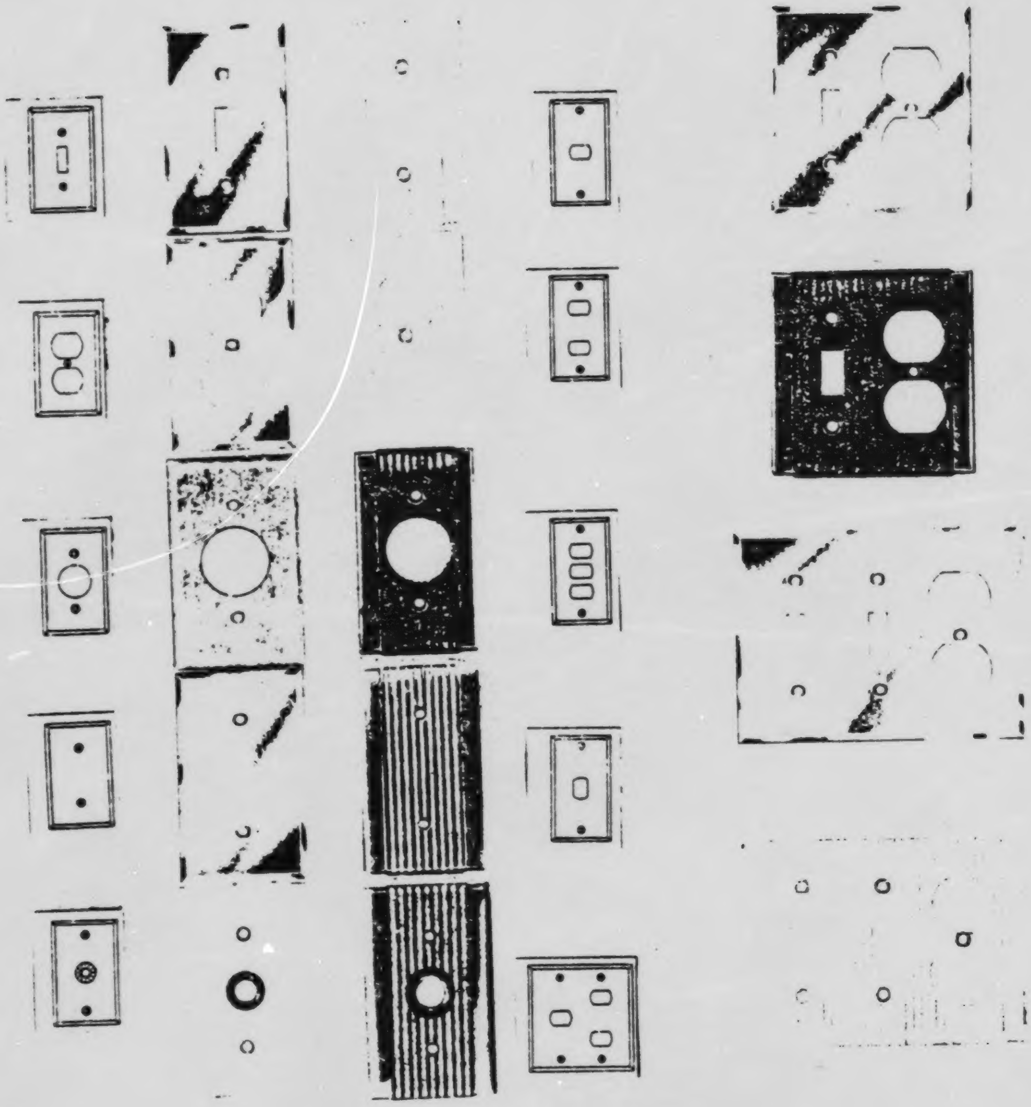












NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 1.3.2.IS.1
CLASS: 4 PRACTICAL: 1

TITLE: BASIC CIRCUITS AND BLUEPRINTS

INTRODUCTION: This information sheet will guide you in the proper steps of procedure for calculating electrical loads and completing electrical wiring diagrams.

INSTRUCTIONAL MATERIALS:

A. Publications

1. Texts:

a. National Electrical Code

b. NAVPERS 10636-G, CE 3 & 2, Chapter 2

c. Programmed Instruction, Series 058/551A, "Electrical Symbols".

2. Reference

a. American Electrician's Handbook, 9th Edition, Croft, Carr and Watt; Mc Graw-Hill Book Co., N. Y., N. Y.

B. Instructional Aids

1. Materials

a. Pencil, ruler

b. Incomplete blueprint

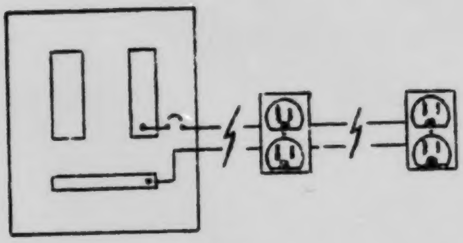
C. Instructor Prepared Materials

1. Completed electrical blueprint display

I. Presentation

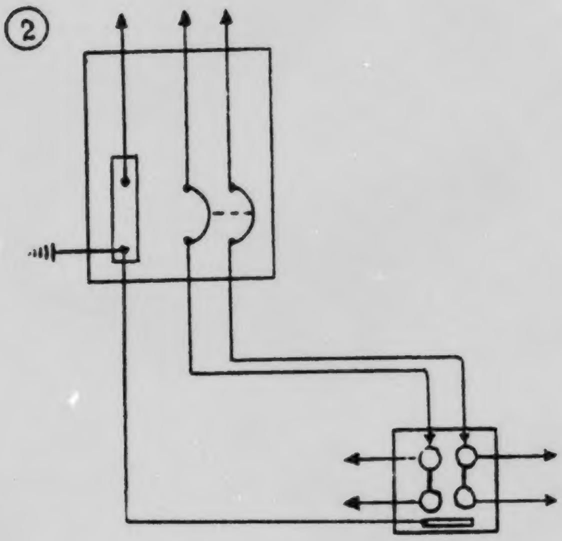
A. Basic Circuits

①



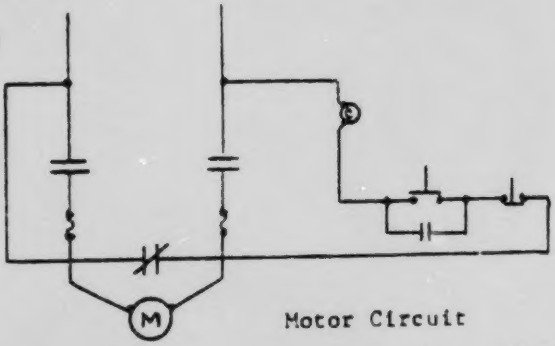
Panel and Branch Circuit

②



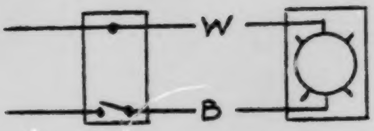
Main Disconnect, Feeder and Branch-Circuit Panel

③



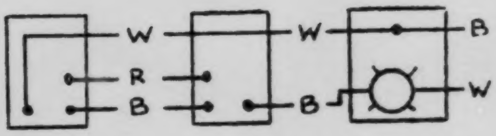
Motor Circuit

④



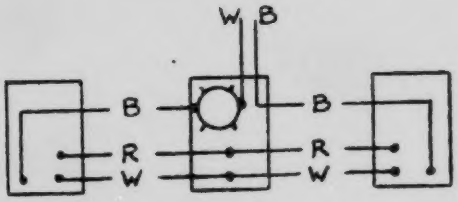
Single-Pole Switch for Light Circuit

⑤



3- and 4-Way Switching

⑥



3- and 4-Way Switching

B. Definitions

1. Refer to: NEC Article 100

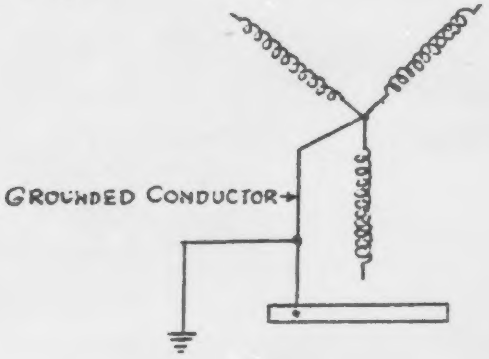
C. Color Code

1. Refer to NEC ARticles 200.6 and 210.5(a) (b) (c)

D. Grounded Conductor

1. Definition: A system or circuit conductor which is intensionally grounded.

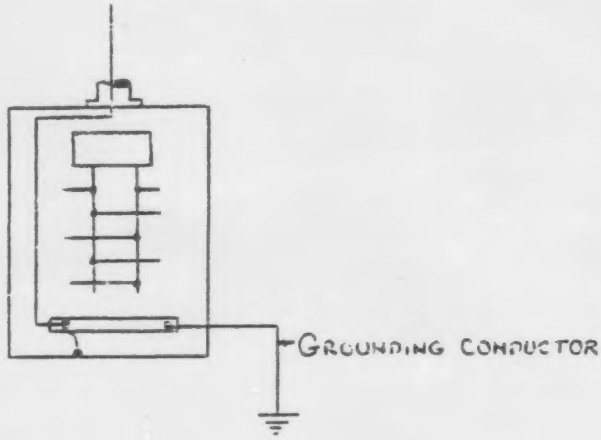
2. Example:



E. Grounding Conductor

1. Definition: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

2. Example:



F. Electrical Symbols

1. Refer to programmed instruction "Electrical Symbols".

G. Voltage

1. To ground: Refer to NEC Article 210.6(a)

2. Between conductors: Refer to NEC Article 210.6(b) (c)

3. Voltage drop: Refer to NEC Article 210.6(d):

4. Voltage drop calculations:

$$VD = \frac{K \times L \times I \times 2}{CM} \qquad CM = \frac{K \times L \times I \times 2}{VD}$$

K = Resistivity of conductor material in OHMS per CM - FT = 12 for copper and 18 for aluminum.
L = Length one way of circuit in feet.
I = Current in amperes.
2 = Number of conductors in circuit.
CM = Area of conductor in circular mils (See NEC Table 8, Chapter 9)

H. Conductors

1. Insulation - TW, THHN, THW, THWN, MTW, MI, AVA. Refer to NEC Tables 310-2(a) "Conductor Application", 310-2(b) "Conductor Insulations".

2. Conductor notes: Refer to NEC notes to Tables 310-12 through 310-15.

3. Ampacity: Refer to NEC, Table 310-12, "Allowable Ampacities of Insulated Copper Conductors".

I. Receptacle Outlets

1. Grounding-type receptacles and protection: Refer to NEC Articles 210-7 and 210-22(a) (b) (c) (d).

   a. Effective January 1, 1973 all 120-volt, single-phase, 15- and 20-amp receptacle outlets installed outdoors on residential properties must have approved personnel ground-fault protection. Such protection can be installed at the panelboard, or may be built into the receptacle. With increased use of electrical appliances outdoors, such as lawn mowers, hedge trimmers, portable radios and Hi-Fi equipment, portable tools and various appliances, shock hazards have been greatly increased in such areas. Ground-fault protection for outdoor receptacles serving such equipment will prevent serious shock hazards and fatalities when faulty equipment is encountered by users.

   The second paragraph of Section 210-22(d) permits the use of ground-fault protection for other circuits, locations, and occupancies. A wider use of such protection should be promoted to reduce line-to-ground shock hazards, which are common with cord-and plug-connected appliances and tools.

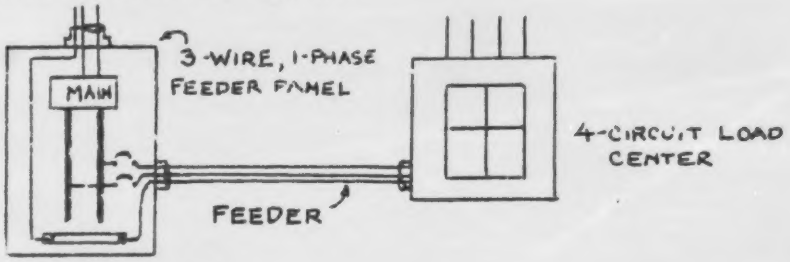
2. Maximum loads: Refer to NEC Article 210-23 (a) (b)

3. Permissible loads: Refer to NEC Article 210-24 (a) (b) (c) (d).

J. Feeders

1. Definition: A feeder is the circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the branch-circuit overcurrent device.

2. Example:



K. Branch-Circuit and Feeder Calculations

1. Lighting loads: Refer to NEC Article 220, Table 220-2(a)

2. Lighting and appliance loads: Refer to NEC Article 220-3.

3. Continuous and non-continuous loads: Refer to NEC Article 220-4(a).

L. Electrical Print

1. See attached drawing.

II. Application

A. A partially completed electrical drawing will be provided for you to make the required calculations, insert the missing symbols and complete the lighting and receptacle circuits.

All work shall be 100% correct.

1.3.3.1

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NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 1.3.~~1~~.JS.1
3

3-16

CLASS: 3 PRACTICAL: 2

TITLE: CONDUCTORS, SPLICES AND CONNECTORS

INTRODUCTION: This job sheet will guide you in the proper procedures when making interior wiring splices and connections.

TOOLS AND EQUIPMENT: Electrician's tool kit, work benches

MATERIALS: One-foot lengths of #12 and #6 conductors, assortment of wire connectors, plastic electrical tape.

PROCEDURES: See attached

QUESTIONS: Instructor Prepared

REFERENCES:

A. NAVPERS 10636-G, CE 3 & 2, Chapter 7
B. American Electrician's Handbook, Croft, Carr and Watt; Mc Craw-Hill Co., N. Y., N. Y., Chapter 2

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Make a splice using; two-one foot lengths of #12 solid copper conductors and a #HS-20 wirenut.	1a. Prepare conductors by stripping 5/8" of insulation from one end of conductor.	1a. Use electrician's knife while adhering to safety rules as per instructor's demonstration.
	1b. Grasp both wires together (with skinned ends even).	1b. Wires may be twisted together or straight.
	1c. Place the wirenut over bare ends and turn in a clockwise direction until tight. (Completed splice shall have no bare copper exposed below the wirenut).	1c. Splice shall be 100% correct.
2. Make a splice using; two-one foot lengths of #12 solid copper conductors, one-one foot length of fixture wire, and a #HS-20 wirenut.	2a. Prepare conductors by stripping 5/8" of insulation from one end of the 2-#12 conductors.	
	2b. Skin 1" of insulation from one end of the fixture wire.	
	2c. Grasp the 2-#12 conductors and wrap (in a clockwise direction) the stranded fixture wire around the 2-#12's.	2c. Ensure that the #12 conductors are even at the ends.
	2d. Turn the wirenut on to the 3 wires and twist in a clockwise direction until tight.	2d. Splice shall be 100% correct .
3. Make a splice using; two-one foot lengths of #6-stranded copper conductors and a #6 split-bolt connector.	3a. Prepare conductors by stripping 1" of insulation from one end of each conductor.	
	3b. Place stripped ends of conductors together and install #6 split-bolt connector.	3b. Split-bolt connector shall be disassembled before installing on conductors as per instructor's demonstration.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	3c. Tighten split-bolt connector using two adjustable open-end wrenches.	3c. Place one wrench on body of the connector and tighten bolt with second wrench. Splice must not slip when pulled by hand.
	3d. Tape finished connection by applying plastic tape until original insulation is replaced.	3d. Splice and taping shall be 100% correct with no exposed copper.

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CEA 1.3.5.IS.1
CLASS: 4

TOPIC: CODE STUDIES

INTRODUCTION: This information sheet will provide the various sections of the code that apply to the electrical material and equipment you will install in Topics 1.3.6 and 1.3.13.

INSTRUCTIONAL MATERIALS:

A. Publications

1. Texts:

a. National Electrical Code, Chapters 1, 2, 3, 4 and 9

b. NAVPERS 10636-G, CE 3 & 2, Chapter 7

I. Presentation

   A. Introduction

      1. Purpose of the code

         a. NEC Article 90-1

         b. History - The National Electrical Code was originally drawn in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests. The original code was prepared by the National Conference on Standard Electrical Rules. Prior to this, acting on an 1881 resolution of the National Association of Fire Engineers' meeting in Richmond, Virginia, a basis for the first code was suggested to cover such items as identification of the white wire, the use of single disconnect devices, and the use of insulated conduit.

      2. Scope

         a. NEC Article 90-2

      3. Examination of Equipment for Safety

         a. NEC Article 90-8

      4. Wiring Planning

         a. NEC Article 90-9

   B. General Guides

      1. Definitions

         a. NEC Article 100

      2. General Requirements

         a. NEC Article 110

   C. Wiring Design and Protection

      1. Use and Identification of Grounded Conductors

         a. NEC Article 200

      2. Branch Circuits

         a. NEC Article 210

3. Feeders
    a. NEC Article 215
4. Branch-Circuit and Feeder Calculations
    a. NEC Article 220
5. Services
    a. NEC Article 230
6. Overcurrent Protection
    a. NEC Article 240
7. Grounding
    a. NEC Article 250

D. Wiring Methods and Materials
1. General Requirements
    a. NEC Article 300
2. Conductors for General Wiring
    a. NEC Article 310
3. Nonmetallic-Sheathed Cable
    a. NEC Article 336
4. Rigid Metal Conduit
    a. NEC Article 346
5. Rigid non-metallic conduit
    a. NEC Article 347
6. Electrical Metallic Tubing
    a. NEC Article 348
7. Outlet, Switch and Junction Boxes, and Fittings
    a. NEC Article 370

8. Switches
    a. NEC Article 380
9. Switchboards and Panelboards
    a. NEC Article 384

E. Equipment for General Use
1. Lighting Fixtures, Lampholders, Lamps, Receptacles and Rosettes
    a. NEC Article 410
2. Motors, Motor Circuits and Controllers
    a. NEC Article 430

F. Tables and Examples
1. Tables and Notes
    a. NEC Chapter 9, A (Tables)
    b. NEC Chapter 9, B (Examples)

II. Practical Application

A. You will apply the appropriate code rulings during the practical application of Topics 1.3.6 and 1.3.13.

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CEA 1.3.5.JS.1

CLASS: 2 PRACT: 13

TITLE: CONDUIT INSTALLATION

INTRODUCTION: This job sheet will guide you in the installing of rigid steel conduit, rigid non-metallic conduit and electrical metallic tubing in a concrete slab area, and cinder block wall.

TOOLS AND EQUIPMENT: Electrician's tool kit, hand and ratchet bender

MATERIALS: Preformed sections of rigid steel conduit, rigid non-metallic conduit and electrical metallic tubing; locknuts, bushings, E.M.T. connectors, couplings, junction boxes, rebar tie-wire and chalk.

PROCEDURES: See attached

QUESTIONS: Instructor prepared

REFERENCES:

A. NAVPERS 10636-G, CE 3 & 2, Chapter 7

B. National Electrical Code, Articles 346 and 348

C. American Electricians Handbook, Croft, Carr and Watt; Mc Graw-Hill Book Co., N. Y., N. Y.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Install rigit conduit (steel or P.V.C.) into a simulated reinforced concrete slab area.	1a. Locate stub-up points on print.	
	1b. Measure distance of conduit run on print and convert to working measurements.	1b. Scale on print. 3/8" = One foot, therefore 3/8" = Distance on print and one foot = Actual distance applied to conduit run.
	1c. Locate conduit run with stakes and chalk.	
	1d. Select preformed sections of conduit for assigned circuit. (Lighting, receptacle or special purpose).	
	1e. Install conduit where indicated with chalk.	
	1f. Secure conduit to rebar at approximately every 3 feet with rebar tie-wire.	
	1g. Apply conduit section from conduit run (in the slab) to panel. Secure to panel with double lock-nuts and bushing.	
	1h. Apply conduit section from conduit run to junction box. Secure to J.B. with double lock-nuts and bushing.	1h. Plug both ends of conduit run with paper or rags to avoid any foreign matter that may be inserted.
	1i. P.V.C. runs located in the slab will require rigid steel 90° stub-ups to panel and junction boxes.	1i. Installations shall be 100% correct.
2. Install electrical metallic tubing.	2a. Measure distance of E.M.T. run between junction boxes as outlined on the print. Convert distance to working measurement.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	2b. Select the proper size and length of E.M.T. and secure to the junction boxes with connectors and locknuts.	2b. Securing the E.M.T to the junction boxes will secure the conduit into position.
	2c. Check all points of connection between conduit-to-panel, conduit-to-conduit, and conduit-to-junction boxes.	2. E.M.T. installations shall be 100% correct.

(3 of 3)

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CE "A"-IS-1.3.5.1

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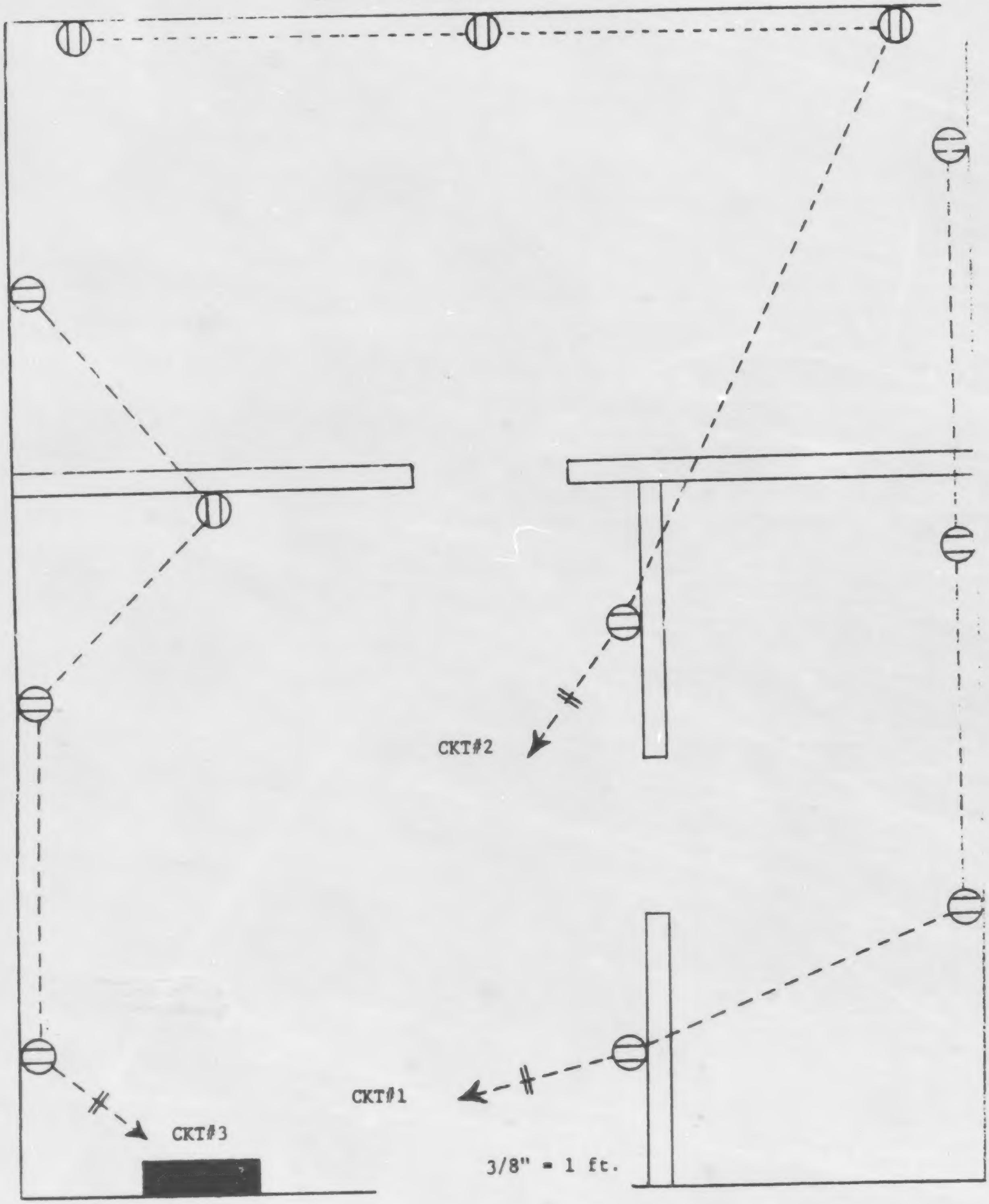
UNDER-SLAB CONDUIT INSTALLATION


CKT#2
CKT#1
CKT#3
3/8" = 1 ft.

NAVAL SCHOOLS, CONSTRUCTION
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CEA 1.3.8.IS.1
CLASS: 3

TOPIC: LIGHT FIXTURES

INTRODUCTION: This information sheet will provide you with the code rulings and drawings that apply to incandescent and flourescent lighting.

INSTRUCTIONAL MATERIALS:

A. Publications

1. Text:

a. National Electrical Code, Article 410

2. Reference:

a. American Electrician's Handbook, 9th Edition, Croft, Carr and Watt; Mc Graw-Hill Book Co., N. Y., N. Y.

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I. Presentation

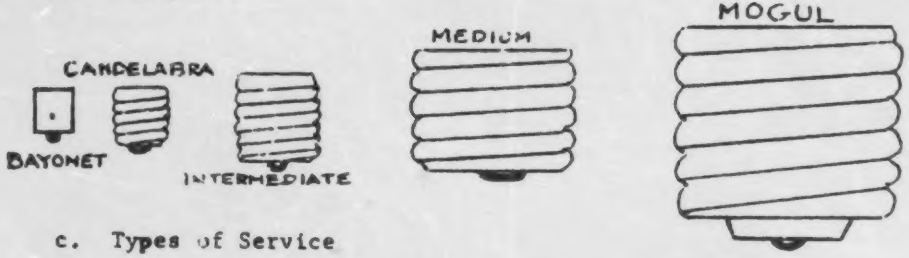
A. Incandescent lighting - Radiant energy of those wave lengths to which the human eye is sensitive. The wave's to which the eye is sensitive are those near the middle of the spectrum, of a length of about 0.0004 to 0.0008 MM.

1. General Rules
   - a. NEC 410-1
2. Provisions for Fixture Locations
   - a. NEC 410-4, Specific Locations
   - b. NEC 410-5, Near Combustible Materials
   - c. NEC 410-6, Over Combustible Material
   - d. NEC 410-8, In Clothes Closets
3. Provisions At Fixture Outlet Boxes, Canopies and Pans.
   - a. NEC 410-11, Temperature Limit of Conductors at Outlet Boxes
4. Fixture Supports
   - a. NEC 410-15, Supports, General
   - b. NEC 410-16, Means of Support
5. Wiring of Fixtures
   - a. NEC 410-17, Fixture Wiring - General
   - b. NEC 410-19, Conductor Insulation
   - c. NEC 410-23, Protection of Conductors and Insulation
   - d. NEC 410-26, Fixture Raceways
   - e. NEC 410-27, Polarization of Fixtures
6. Installation of Lampholders
   - a. NEC 410-41, Screw-Shell Type
   - b. NEC 410-43, Lampholders in Damp or Wet Locations

7. Lamps

   a. NEC 410-49, Bases, Incandescent Lamps

   b. Examples:



   c. Types of Service

      (1) Clear bulb

      (2) Inside-frosted bulb

      (3) White bowl bulb

      (4) Silvered-bowl bulb

   d. Miscellaneous Lighting Service Lamps

      (1) Appliance - and indicator-service

      (2) Aviation - service

      (3) Country - home

      (4) High-voltage

      (5) Low-voltage

      (6) Marine-service

      (7) Mine-service

      (8) Optical-service

      (9) Photographic-service

      (10) Photo-service

      (11) Picture-projection

      (12) Sign

      (13) Spotlight-and floodlight-service lamps

(14) Street-lighting service

(15) Traffic-signal

B. Flourescent lighting-An electronic form of lighting that functions through conduction in a gas.

1. Fixture Mounting

    a. NEC 410-74, Fixture Mounting

        (1) Exposed ballasts

        (2) Combustible low-density cellulose fiberboard

2. Grounding

    a. NEC 410-92, Metallic Wiring Systems

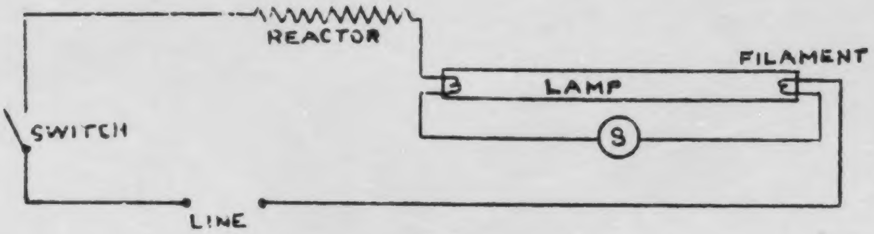
    b. NEC 410-93, Non-metallic Wiring Systems

    c. NEC 410-95, Equipment Near Grounded Surfaces

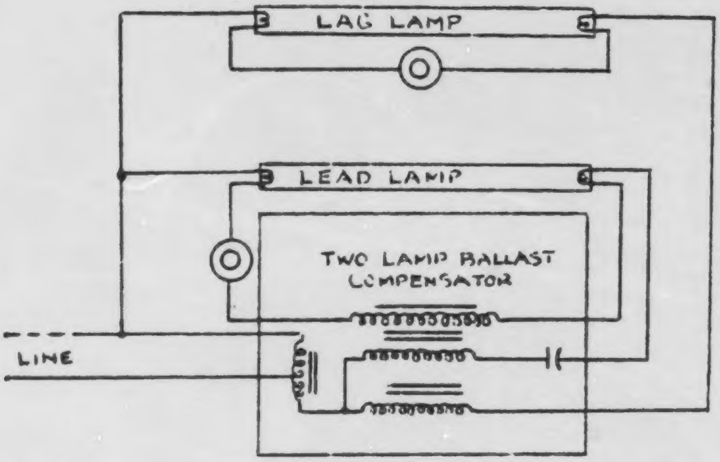
    d. NEC 410-96, Methods of grounding

3. Internal Wiring

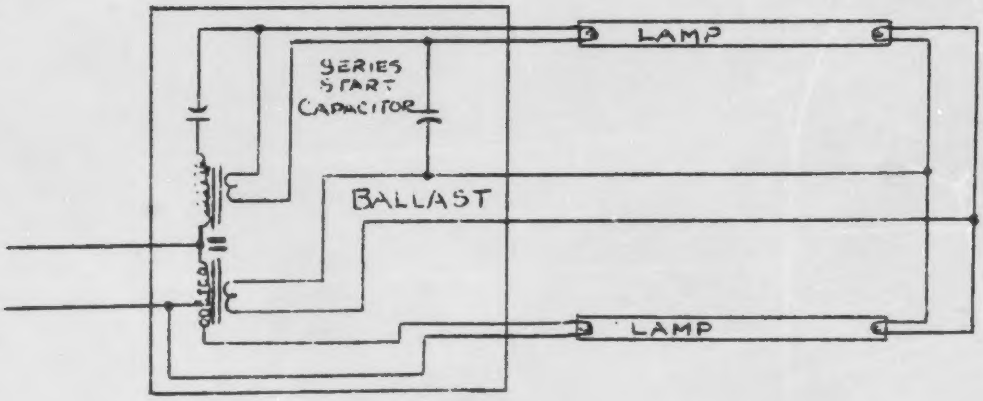
a. Lamp with simple reactor


REACTOR
FILAMENT
LAMP
SWITCH
S
LINE

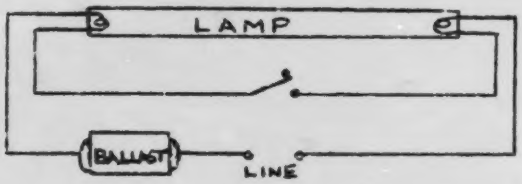
b. Two-lamp lead-lag preheat


LAG LAMP
LEAD LAMP
TWO LAMP BALLAST
COMPENSATOR
LINE

c. Two-lamp series rapid start


LAMP
SERIES
START
CAPACITOR
BALLAST
LAMP

d. Flourescent lamp circuit with push-button starting switch


LAMP
BALLAST
LINE

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CEA 1.3.~~10~~9 JS.1
CLASS: 1 PRACTICAL: 3

TITLE: TEMPORARY WIRING

INTRODUCTION: This job sheet will guide you in the proper steps of procedure to install, test, and use a temporary power pole assembly.

TOOLS AND EQUIPMENT: Electrician's tool kit, temporary power pole assembly (50 amp), temporary power panel and cord assembly (50 amp), digging tools, 20-foot extension ladder, 5-foot step ladder, 8-foot X 5/8" copperweld ground rod, grounding conductor #8 AWG and 1/2" rigid steel conduit.

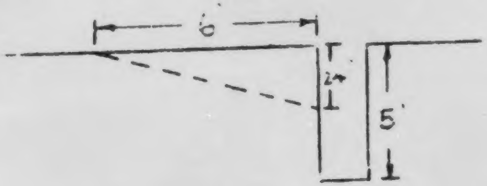
MATERIALS: Mechanical connectors, electrical tape, ground clamp.

PROCEDURES: See attached

QUESTIONS: Instructor prepared

REFERENCES:

A. National Electrical Code, Articles 210 and 305

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Install temporary power pole assembly.	1a. Location of pole shall be 18' north of northwest corner of the "conduit-wiring-in-slab area" building.	
	1b. Use appropriate digging tools and dig a 12" diameter by 5' min. deep hole with a sloping trench to the hole approx. 6' long by 10" wide (as per drawing).  	1b. Digging tools include; pick, shovel (D-Handle), tamping bar, long handle shovel, and scoop shovel.
	1c. Use 2" X 10" x 8' butt board in the hole.	
	1d. With the pre-assembled pole butted up against the butt board, in the sloping trench, two men on each side of pole will raise and set the assembly into the hole.	
	1e. Four men, each positioned 90° apart around the pole, will support the pole in a vertical position with pike poles.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	1f. One shoveler and one tamper; replace all the dirt back in the hole around the pole.	
2. Install grounding system.	2a. Select an 8' X 5/8" copperweld ground rod and position it approx. 12" to the right side of the pole while facing the panel.	
	2b. Use a 5-foot stepladder for required height when hammering ground rod into the ground.	
	2c. Select the preformed 1/2" rigid steel conduit with threaded ends and one 90° bend.	
	2d. Install ground clamp assembly on 90° end.	
	2e. Secure straight end to knock out in panel with double-locknut and bushing.	
	2f. Secure ground clamp to ground rod.	
	2g. Install #8 AWG bare copper conductor and connect to neutral bar in the panel, and to ground clamp.	
	2h. Secure 1/2" conduit with 2-1/2" rigid steel conduit straps. (Use wood screws).	

WHAT TO DO	HOW TO DO IT	KEY POINTS
3. Connect service drop to Bldg. 120.	3a. Position 20 foot ladder against rear of Bldg. 120. 3b. Secure the 3 - #8 insulated conductors (from the temporary power pole) to the insulator rack attached to the building. 3c. Ensure that the service power is "Off" before making the 3 connections.	
4. Test circuits	4a. Connect extension cord with required twist-lock, 3-prong plug and check cord assembly with a Wiggin's voltage tester.	
	4b. Using a 40-watt light bulb and test socket, connect one lead to hot terminal of receptacle. Touch other lead of test light to ground.	4b. Circuit breaker (ground fault circuit interrupter) will trip immediately to indicate proper operation of mechanism. Installation and testing will be executed 100% correct.

1.3.10.1
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CEA 1.3.11.JS.1
10
CLASS: 5 PRACTICAL: 2

TITLE: HAND TOOLS AND TEST EQUIPMENT

INTRODUCTION: This job sheet will guide you in the proper steps of procedure when using test equipment to locate grounds and shorts in lighting and receptacle circuits.

TOOLS AND EQUIPMENT: Electrician's tool kit, voltage tester (Wiggins), multimeter.

MATERIALS: Prewired circuits (lighting and receptacle), electrical tape.

PROCEDURES: See attached

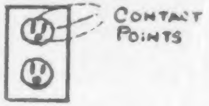
QUESTIONS: Instructor prepared

REFERENCES:

A. NAVPERS 10636-G, CE 3 & 2, Chapter 4

B. NAVPERS 10085-B, Tools and Their Uses

(1 of 4)

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Test an interior wiring system for continuity using the voltage tester (Wiggins).	1a. Main Disconnect - With the breaker in the Off position, place the test leads on the incoming line leads L_1 and L_2. Voltage reading shall be approximately 220 volts. 1b. Place the main disconnect and all circuit disconnects into the On position. If any circuit disconnect trips to the tripped position, make note of the circuit for further testing.	
	1c. Check the remaining circuits for continuity by using the following procedures: Lighting Circuit - Check hot lead to ground at lighting fixture (115V). Turn wall switch On, and check voltage to ground on both terminals of switch - Should indicate 115V. Receptacle Circuit - At each outlet check between each contact point and ground.  	1c. If lighting circuit feed goes to the lighting fixture first, then start at the fixture.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	115 V. Should be read between the smaller of the two parallel slots and ground.	
2. Locate a ground in the circuit (with the tripped breaker) using an Ohmmeter.	2a. Ensure that all circuit breakers are Off, including the main.	2a. Short - Two wires in a cable or conduit making direct contact with each other. Ground - A conductor making direct contact with metallic junction boxes or raceways.
	2b. Disconnect circuit from panel by removing circuit breaker with conductor attached.	
	2c. Remove circuit neutral conductor from neutral bar.	
	2d. Place test leads on the neutral conductor and ground. If a zero reading is obtained, the neutral is grounded somewhere in the circuit.	2d. On a lighting circuit, ensure that all light switches are in the On position and all light bulbs taken out of their sockets.
	2e. Open circuit at the half-way junction box and determine which section is grounded.	
	2f. Continue process of elimination until grounded conductor is located.	2f. At all points of testing use test leads between the neutral or circuit conductor (whichever is grounded) and any metal portion of the circuit.

WHAT TO DO	HOW TO DO IT	KEY POINTS
3. Locate a short in a second circuit (with a tripped breaker) using an Ohmmeter.	3a. Ensure that all circuit breakers are Off, including the main. 3b. Disconnect circuit from panel by removing circuit breaker with conductor attached. 3c. Remove circuit neutral conductor from neutral bar.	
	3d. Place test leads on neutral conductor and the lead connected to the circuit breaker. Meter will read ZERO if a short exists.	3d. Ensure that all light bulbs are removed.
	3e. Open circuit at the half-way junction box and determine which section is shorted.	
4. Repair grounded and shorted circuits.	4a. Correct the ground and the shorted condition in each circuit with several wraps of electrical tape.	4a. Test procedures and cable repairs shall be executed 100% correct.
	4b. Energize circuits by placing main breaker and the lighting and receptacle circuit breakers in the "On" position. 4c. Test all circuits for normal operation.	

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CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

INFORMATION SHEET

TITLE: Single Phase Motors

INTRODUCTION: This information sheet will require identification fill-ins on various single phase motor drawings.

TEXTS:

1. Construction Electrician 3 & 2, NAVPERS 10636-G.
2. National Electrical Code, Article 430.
3. Allen-Bradley Manual, "Wiring Diagrams for Full Voltage Starting Switches".

TOOLS, EQUIPMENT AND MATERIALS:

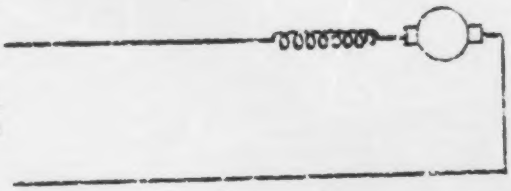
1. Pencil.
2. Ruler.

LOCALLY PREPARED MATERIALS:

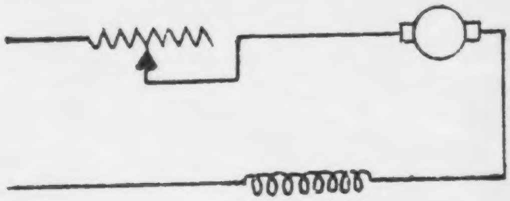
1. Incomplete single phase motor drawings.
2. Cutaway of single phase A.C. motor.

PRESENTATION

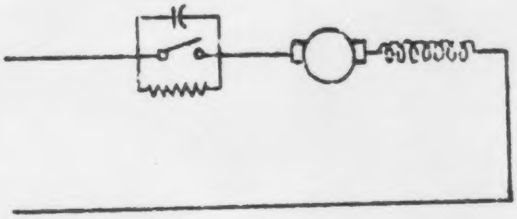
1. Series or Universal
(Portable Handtools
and appliances)



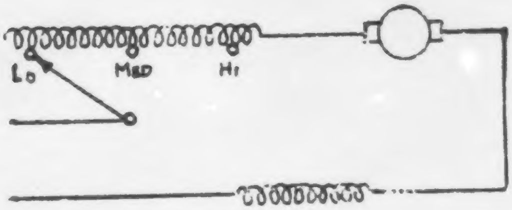
a. Resistance



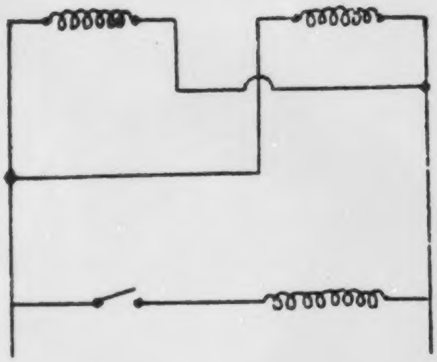
b. Centrifugal
Device



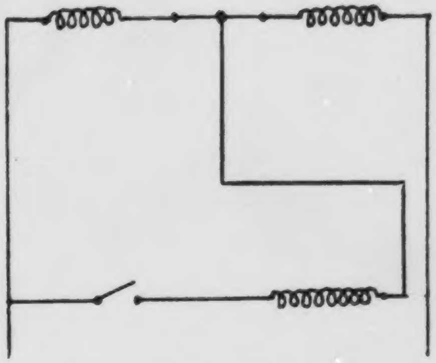
c. Tapped field



STRAIGHT SPLIT-PHASE MOTOR

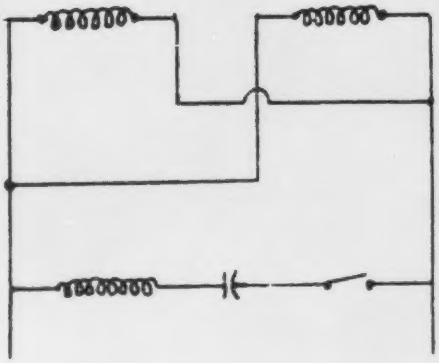


LOW VOLTAGE HOOK-UP

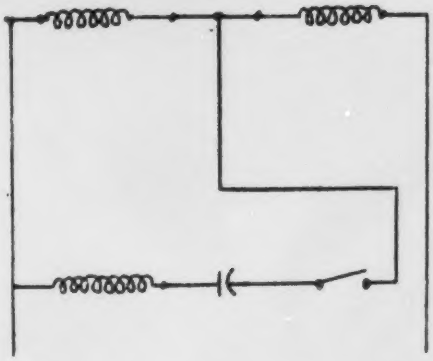


HIGH VOLTAGE HOOK-UP

CAPACITOR-START, SPLIT-PHASE MOTOR



LOW VOLTAGE HOOK-UP



HIGH VOLTAGE HOOK-UP

(3 of 3)

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NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

INFORMATION SHEET

TITLE: Three Phase Motors

INTRODUCTION: This information sheet will require identification fill-ins on various three phase motor drawings.

TEXTS:

1. Construction Electrician 3 & 2, NAVPERS 10636-G.
2. National Electrical Code, Article 430.
3. Allen-Bradley Manual, "Wiring Diagrams for Full-Voltage Starting Switches".

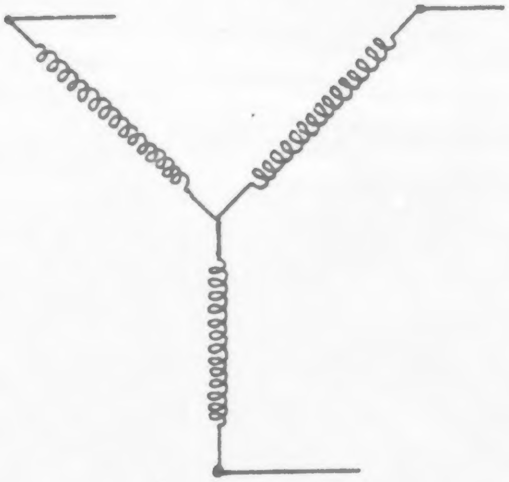
TOOLS, EQUIPMENT AND MATERIALS:

1. Pencil.
2. Ruler.

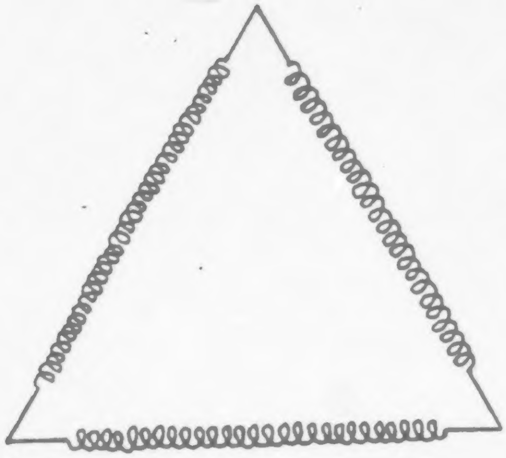
LOCALLY PREPARED MATERIALS:

1. Incomplete three phase motor drawings.

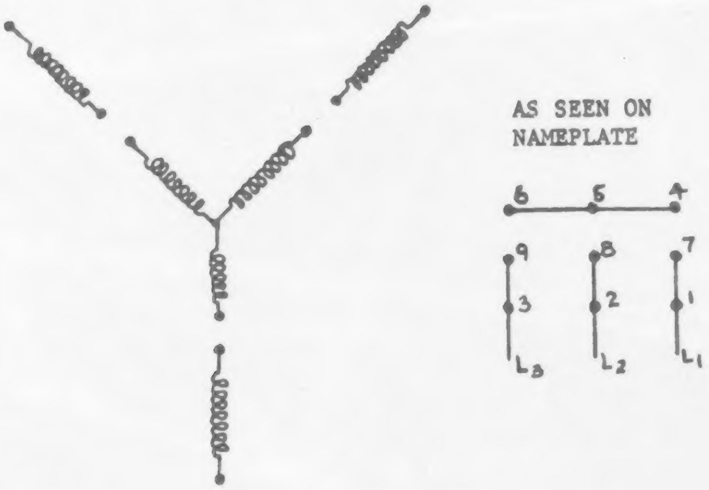
PRESENTATION:



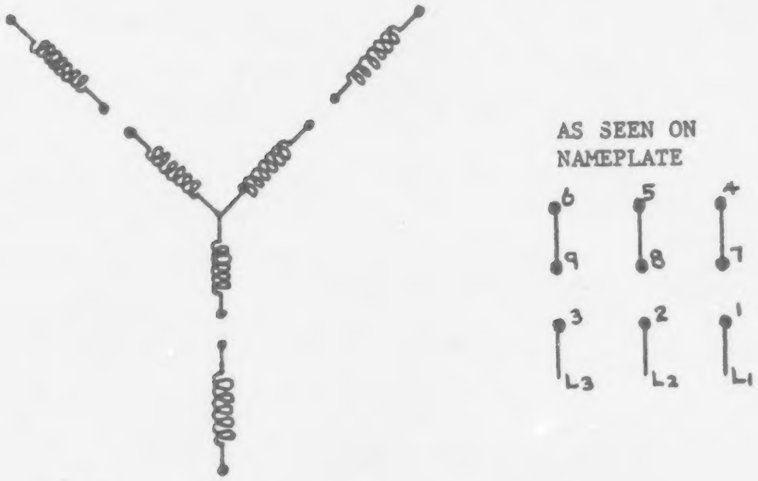
THREE PHASE Y -CONNECTED SINGLE VOLTAGE MOTOR



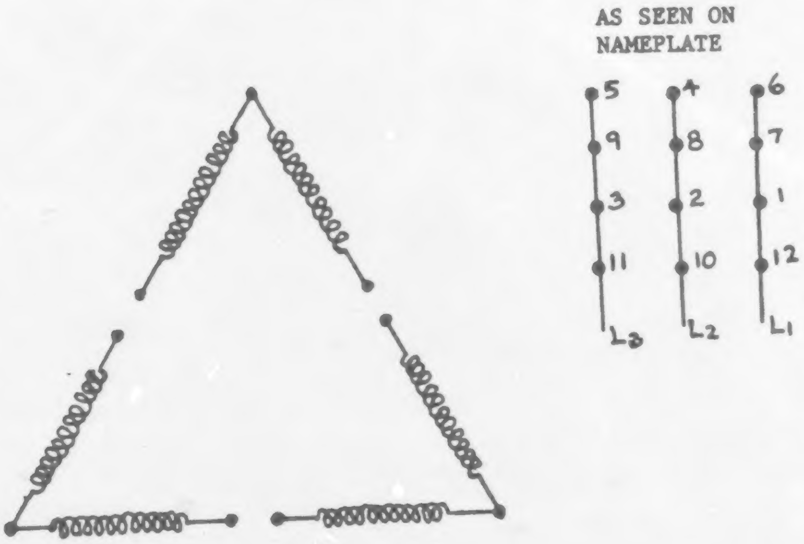
THREE PHASE △-CONNECTED SINGLE VOLTAGE MOTOR


AS SEEN ON NAMEPLATE
6
5
4
9
8
7
3
2
1
L3
L2
L1

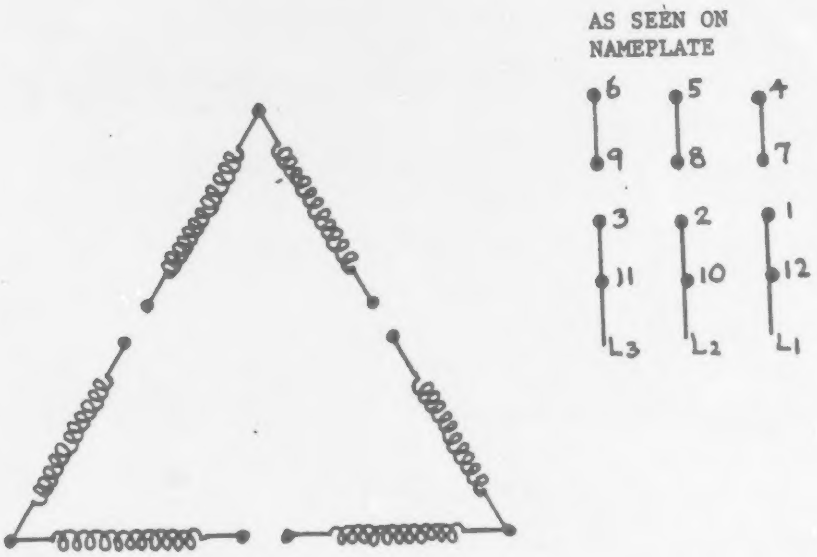
THREE PHASE Y - CONNECTED DUAL VOLTAGE MOTOR
(LOW VOLTAGE)


AS SEEN ON NAMEPLATE
6
5
4
9
8
7
3
2
1
L3
L2
L1

THREE PHASE Y - CONNECTED DUAL VOLTAGE MOTOR
(HIGH VOLTAGE)


AS SEEN ON NAMEPLATE
5
9
3
11
L3
4
8
2
10
L2
6
7
1
12
L1

THREE PHASE Δ- CONNECTED DUAL VOLTAGE MOTOR
(LOW VOLTAGE)


AS SEEN ON NAMEPLATE
6
9
5
8
4
7
3
11
L3
2
10
L2
1
12
L1

THREE PHASE Δ -CONNECTED DUAL VOLTAGE MOTOR
(HIGH VOLTAGE)

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CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

INFORMATION SHEET

TITLE: Motor Control

INTRODUCTION: This information sheet will require identification fill-ins on various motor control drawings.

TEXTS:

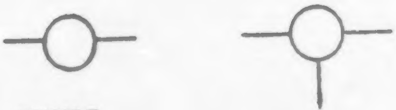
1. Construction Electrician 3 & 2, NAVPERS 10636-G.
2. National Electrical Code, Article 430.
3. Allen-Bradley Manual, "Wiring Diagrams for Full-Voltage Starting Switches".

TOOLS, EQUIPMENT AND MATERIALS:

1. Pencil.
2. Ruler.

LOCALLY PREPARED MATERIAL:

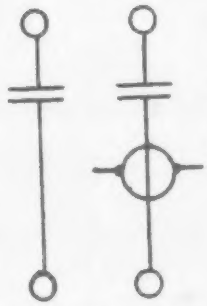
1. Incomplete motor control drawings.



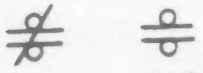
SINGLE WINDING

TAPPED

OPERATING COILS



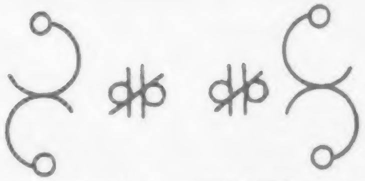
MAIN CONTACTS



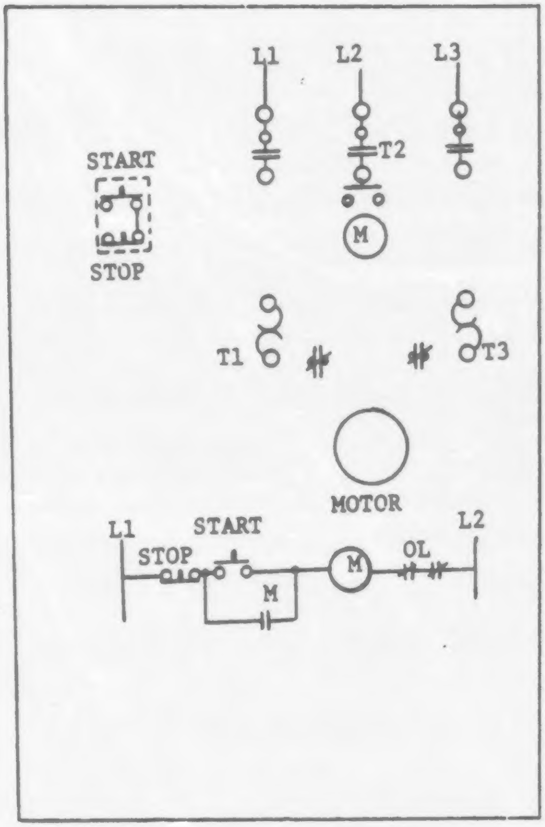
(NC)

(NO)

AUXILARY CONTACTS



THERMAL OVERLOADS


L1
L2
L3
START
T2
STOP
M
T1
T3
MOTOR
L1
START
L2
STOP
M
OL
M

3 PHASE STARTER WITH START-STOP PUSH BUTTON STATION

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CEA 1.3.12.JS.1
12

CLASS: 1 PRACTICAL: 27

TITLE: CUBICLE WIRING

INTRODUCTION: This job sheet will guide you in the proper procedures for wiring a three-room cubicle with receptable, lighting and motor circuits.

TOOLS AND EQUIPMENT: Electricians tool kit, hand bender

MATERIALS: Boxes, fittings, motor, motor controller with push-button station, circuit breaker panel; rigid steel, plastic and flexible conduit, electrical metallic tubing, non-metallic sheathed cable, electrical devices, lighting fixtures.

PROCEDURES: See attached

REFERENCES:

A. NAVPERS 10636-G, CE 3 & 2, Chapter 7

B. National Electrical Code, Afticle 300

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Make a list of materials required to install Circuits #1 - 4.	1a. Count the number and type of boxes for the lighting receptacle and motor circuits.	1a. Material listing will be compiled from the attached drawing, and footage of conduit and conductors will be in accordance with the scale thereon.
	1b. Estimate the amount of conduit, single conductor wire, and non-metallic sheathed cable.	
	1c. Determine the fittings required to connect the conduit and cable to their appropriate junction boxes.	
	1d. Estimate the amount of wood screws, staples and other hardware necessary to secure the wiring.	
	1e. List all switches, outlets, lighting fixtures, plates, and the motor with associated control equipment.	
	1f. Submit the list of material to the material issue room and ensure that all boxes, fittings and hardware are complete after receipt of issue. Check out a complete set of electrician's tools and sign the custody card.	
2. Install outlet and junction boxes for Circuits #1 - 4.	2a. Circuit #1 - Using wood screws, install the 2 - 2-1/4" X 2" gem boxes in the locations outlined on the print.	2a. Boxes shall be mounted for 1/2" wallboard finish. All receptacles shall be 12" to center above finished floor.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	2b. Circuit #2 - Using wood screws; install the 3 - 2-1/4" X 2" gem boxes in the locations outlined on the print.	
	2c. Circuit #3 - Using 1/2" roofing shingle nails, secure the 4/S X 2-1/8" deep box and hanger assembly to be used for the flourescent fixture installation. Location shall be in accordance with the print.	2c. Position the bar hanger to allow for 1/2" wallboard finish.
	Where print indicates "S_3" (3-way switches), mount a 2-1/4" X 2" gem box at each location.	Note: Switch boxes shall be mounted 48" to center above finished floor.
	Where print indicates "S_4" (4-way switch), mount a 4/S X 1-1/2" deep box with a single-gang plaster ring.	
	2d. Circuit #4 - Using wood screws, mount the motor controller as per location on the print.	3a. Motor controller shall be mounted 5' - 6" to center above finished floor.
	Install stop-start station below the motor controller with a 1/2" off-set nipple and locknuts at both ends.	
	Install a 4/11 X 1-1/2" deep junction box approx. 2-feet from the motor, in-line with the run to the controller.	Run from the controller to 4/11 box shall be 1/2" E.M.T. From box to motor shall be 1/2" flexible conduit.

WHAT TO DO	HOW TO DO IT	KEY POINTS
3. Install non-metallic-sheathed cable, Type NMC, 2-conductor #12 Copper with ground (Circuits #1 and #2).	3a. From panel to first outlet: At panel, skin the cable back approx. 12", install cable connector on cable, insert conductors into panel knockout and secure connector with locknut.	3a. Use extreme care when using cable skinning tool, "Do not damage insulation on conductors".
	3b. Route the cable to the first outlet following the shortest practical path.	3b. Keep cable free of kinks.
	3c. Skin cable end approx. 6" and install cable connector on cable. Secure connector to junction box with locknut.	
	3d. Secure cable to studs with 2 staples, one at each end approx. 12 inches from box/panel.	
	3e. Install cable to remaining outlets on Circuits #1 and #2 using procedures outlined in 3a - 3d.	
4. Install 1/2" flexible metallic conduit from S_4 to flourescent light junction box. (Circuit #3, Switch Leg #3).	4a. Select correct length of flexible conduit and install one end at the lighting outlet using a flexible conduit connector and locknut.	
	4b. Route the conduit as outlined on the print. Secure conduit to S_4 switch box as per 4a.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	4c. Secure conduit to studs using conduit straps - one within 12 inches of switch box and one in close proximity to the lighting outlet.	4c. Secure conduit straps with 1/2" shingle nails.
5. Install 1/2" flexible metallic conduit from motor to junction box (Circuit #4).	5a. Select length of flexible conduit (approx. 2-ft. long) and install one end at the motor terminal box.	
	5b. Secure other end to 4/11 X 1-1/2" deep junction box.	5b. Do not secure this length of conduit with a strap. Flexibility required for motor vibration.
6. Install 1/2" electrical metallic tubing from S_3 to flourescent light junction box. (Circuit #3, Switch Leg #2).	6a. Use the 6' - folding rule to measure the distance from the Flourescent light junction box to S_3 (Switch Leg #2).	6a. The conduit run shall be run concealed in the attic space and the wall partition.
	6b. Select one or two lengths of 1/2" E.M.T. as required.	
	6c. First step - Form a 6" stub-up on one end of conduit following the measuring and bending procedures outlined in the attached drawing titled "Accurate Stubs".	6c. Locate a small piece of 1/2" E.M.T. and practice with your assigned hand bender. Note: Take-up measurement varies between different benders.
	6d. Second Step - Form a back-to-back bend with the first 90° bend (6" stub-up) following the measuring and bending procedures outlined in the attached drawing titled "back-to-back bends".	6d. With a scrap piece of E.M.T. practice making a back-to-back bend to exactly 2 feet.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	6e. Install conduit with short stubs and E.M.T. connector to lighting outlet box. Long stub will enter hole in top plate.above S_3.	
	6f. In the second piece of conduit, bend an offset near one end. Amount of offset will depend upon location of knock-out in S_3 gem box.	
	6g. Measure distance between top of switch box and end of conduit, subtract 1/8", cut and ream, and secure conduit ends together with a coupling. Secure conduit run to switchbox with a connector and locknut.	
7. Install non-metallic-sheathed cable, Type NMC 3-conductor #12 copper with ground. (Circuit #3, Switch Leg #1).	7a. Use same procedures as outlined for Circuits #1 and #2.	7a. Select the piece of 3-conductor cable that would be close to your measurement from S_3 to lighting outlet.
8. Install 1/2" electrical metallic tubing for home run (Circuit #3).	8a. Use same procedures as outlined for Item #6 (Circuit #3, Switch Leg #2). Start from lighting outlet.	
9. Install Type TW conductors between panel and lighting outlet (Circuit #3, home run).	9a. Insert fish tape into Circuit #3's E.M.T. home run at the panel. Push until 12" or end is exposed at lighting outlet box.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	9b. Skin the ends of 1-White and 1-Black, Type TW, #12 conductors approx. 3". Bend the exposed copper at the insulation and install on the fish tape. Apply 3 or 4 wraps of electrical tape up and down the connection.	
	9c. Pull fish tape at panel until approx. 12" of wire is exposed.	9c. While one man is pulling on the fish tape, an assistant is applying pressure on the conductors at the J.B.
	9d. Leave approximately 6" of free length when cutting the conductors from the rolls.	9c. Remove tape on fish tape and prepare for Item #10.
10. Install Type TW conductors between S_4 and lighting outlet (Circuit #3, Switch Leg #3).	10a. Select 2-coils of Red, and 2-coils of Blue, Type TW #12 single conductor wire.	
	10b. Insert fish tape into flexible conduit at the lighting outlet and push until 12" of end is exposed at S_4 switch box.	
	10c. Follow procedures in Item #9 for securing conductors to fish tape and pulling in conduit.	10c. Remove tape on fish tape and prepare for Item #11.
11. Install Type TW conductors between S_3 and lighting outlet. (Circuit #3, Switch Leg #2).	11a. Select 1-coil of Black, 1-coil of Blue, Type TW #12 single conductor wire.	

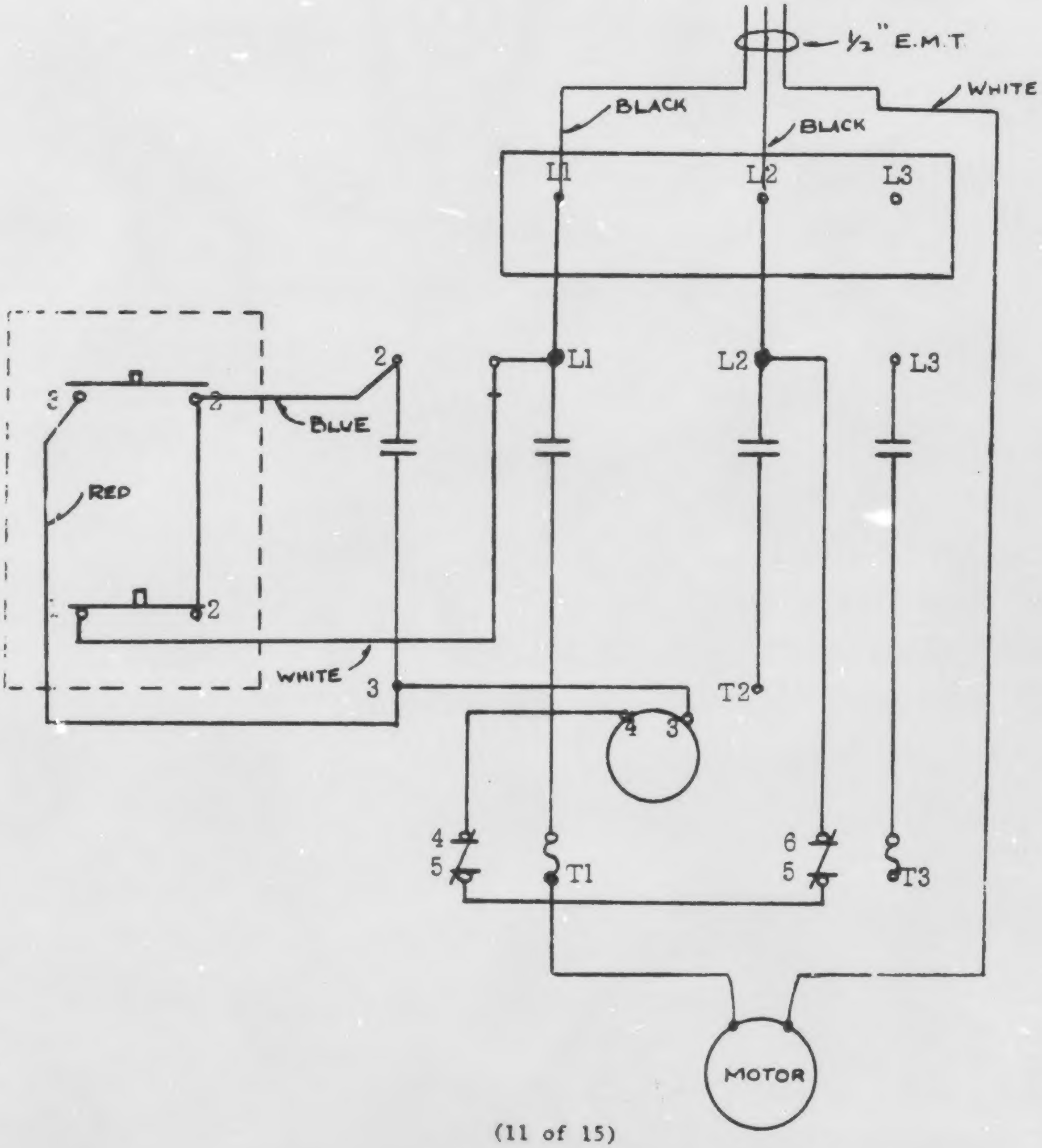
WHAT TO DO	HOW TO DO IT	KEY POINTS
	11b. Insert fish tape into E.M.T. at the lighting outlet and push until 12" of end is exposed at S_3 switch box.	
	11c. Follow procedures in Item #9 for securing conductors to fish tape and pulling in conduit.	11c. Remove tape on fish tape and ensure that 6" of free length of conductor is in the box.
12. Install 1/2" electrical metallic tubing from motor controller to junction box. (Circuit #4)	12b. Conduit shall be run "surface mount" from top of controller to concealed run in the attic.	
	12c. Starting at controller, measure for offset and bend as required in one end of conduit.	
	12d. Measure distance from top of controller to top of ceiling joist. Lay out measurements according to attached drawing "Accurate Stubs".	
	12e. Make 90° bend and place offset end with connector into controller knockout.	12e. Do not install locknut at this time.
	12f. Position conduit and mark with pencil 1/8" from edge of junction box at the knockout.	
	12g. Cut, ream, and install connector.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	12h. Secure both ends with locknuts and strap conduit above controller using 1/2" E.M.T. Strap and 1/2" shingle nails.	
13. Install 1/2" electrical metallic tubing from panel to junction box. (Circuit #4-home run).	13a. Conduit shall be run concealed in stud area above the panel.	
	13b. Use available short pieces of 1/2" E.M.T. for the 90° stub bend from panel and offset to junction box.	
14. Install Type TW conductors between panel to motor junction box, and from junction box to controller.	14a. Insert fish tape into E.M.T. at junction box and push until 12" of end is exposed at the panel.	
	14b. Skin the ends of 2-Black, and 1-White, Type TW, #12 conductors. Follow installation procedures outlined in Item #9.	14b. Remove tape on fish tape and prepare for Item #14c.
	14c. Insert fish tape into E.M.T. at junction box and push until 12" of end is exposed at the controller.	
	14d. Skin the ends of 3-Black, Type TW #12 conductors and repeat Item #9 procedures.	
15. Install Type TW conductors between controller and push-button station (Circuit #4).	15a. Install 1-White, 1-Black and 1-Red, Type TW, #12 conductors. Determine length by estimating distance by routing each conductor from terminal to terminal. Cut, skin and secure each in accordance with attached drawing titled "1Ø Motor Controller Connections".	

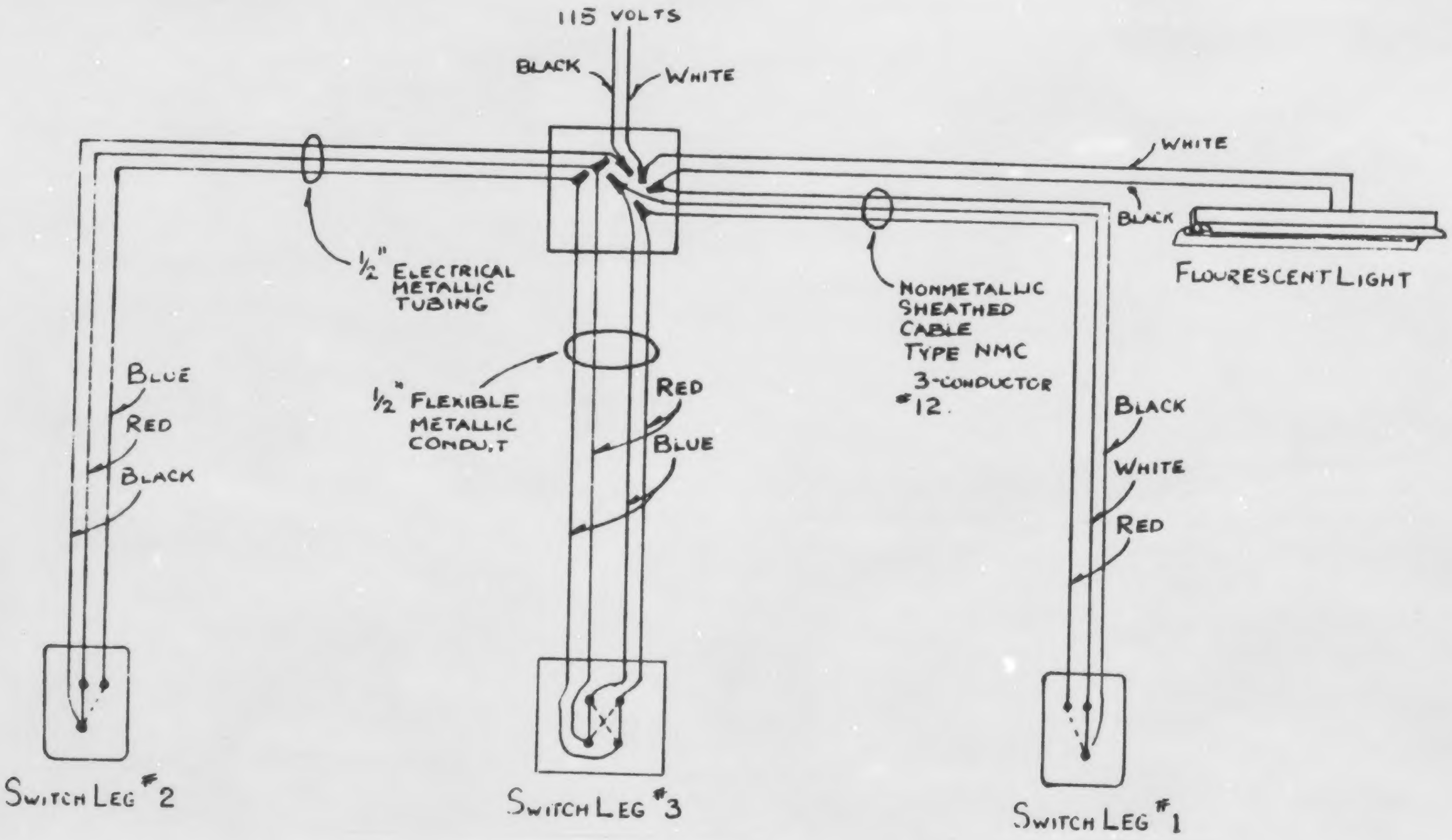
WHAT TO DO	HOW TO DO IT	KEY POINTS
16. Connect circuit conductors at motor controller and motor. (Circuit #4)	16a. Follow the attached diagram titled "10 Motor Controller Connections" for controller and motor connections.	16a. Ensure that all connections at controller are made in a clockwise direction.
17. Connect all switches and make the necessary splices. (Circuit #3).	17a. Follow the attached diagram titled "3 and 4-way Circuit Diagram for Circuit #3).	17a. Rough wiring inspection for evaluation will be done upon completion of installing switches, outlets motor circuit and light installation shall be 100% correct.
18. Complete installation with switch and receptacle plates, covers and fixture assembly.	18a. Follow examples outlined on display board.	
19. Test all circuits.	19a. Energize panel: Place main disconnect in On position.	
	19b. Circuits #1 and #2: Turn on Circuits #1 and #2 breakers and test each outlet for presence of 115 volts between parallel slots, and small slot to ground. Should read 115 volts.	
	19c. Circuit #3 - Turn on Circuit #3 breaker and test each light switch for proper operation.	
	19d. Circuit #4 - Turn on Circuit #4 breaker and test motor circuit for on-off operation via push button.	19d. All circuits shall operate 100% correct.

Construction Electrician's School

SINGLE PHASE
Motor Controller Connections


½" E.M.T.
WHITE
BLACK
BLACK
L1
L2
L3
2
3
2
BLUE
RED
1
2
WHITE
3
L1
L2
L3
T2
4
3
4
5
T1
6
5
T3
MOTOR

CONSTRUCTION ELECTRICIAN'S SCHOOL

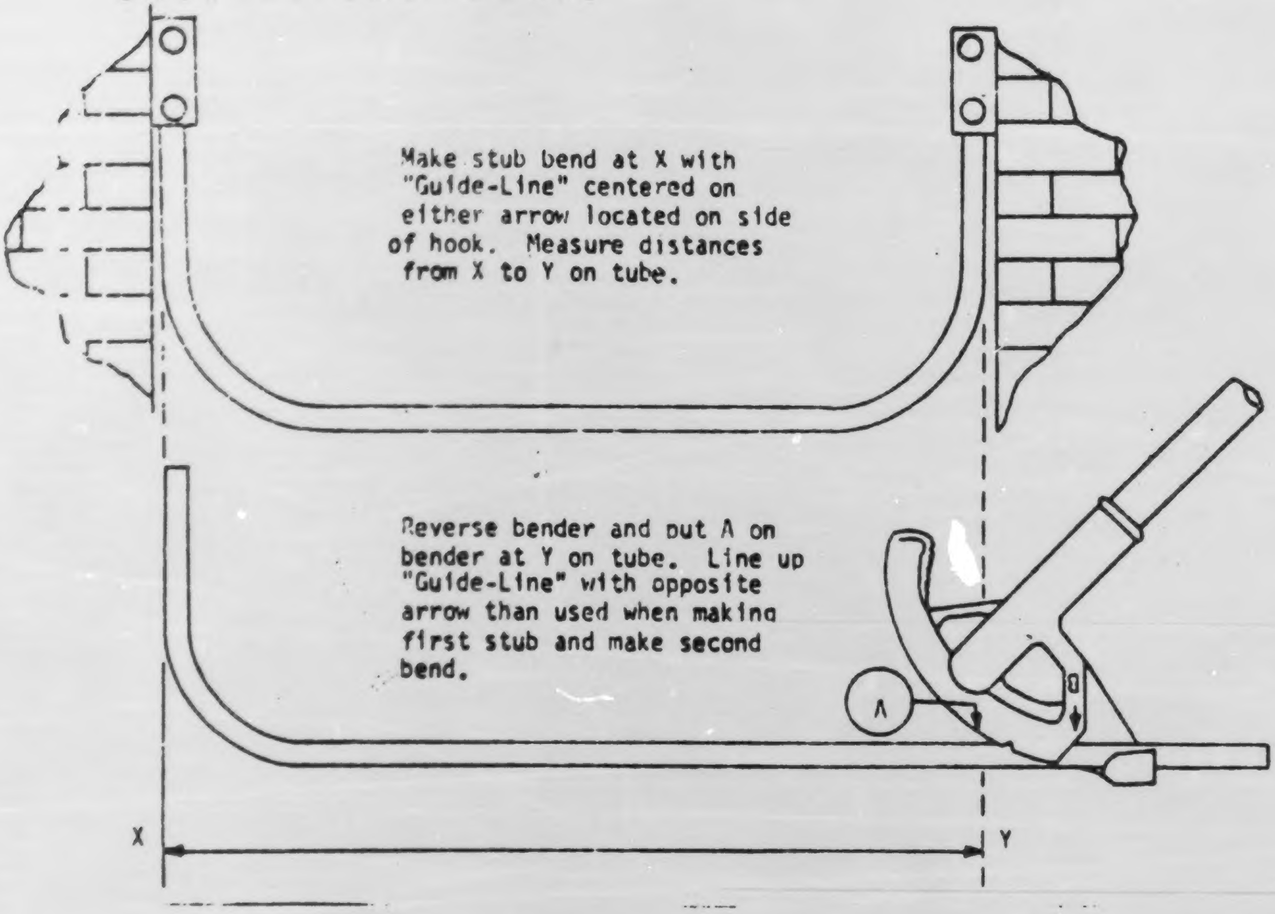

115 VOLTS
BLACK
WHITE
WHITE
BLACK
FLOURESCENT LIGHT
1/2" ELECTRICAL METALLIC TUBING
NONMETALLIC SHEATHED CABLE TYPE NMC 3-CONDUCTOR #12.
1/2" FLEXIBLE METALLIC CONDUIT
BLUE
RED
BLACK
RED
BLUE
BLACK
WHITE
RED
SWITCH LEG #2
SWITCH LEG #3
SWITCH LEG #1

" 3 and 4 Way Circuit Diagram for Circuit #3 "

(12 31 15)

CONDUIT BENDING

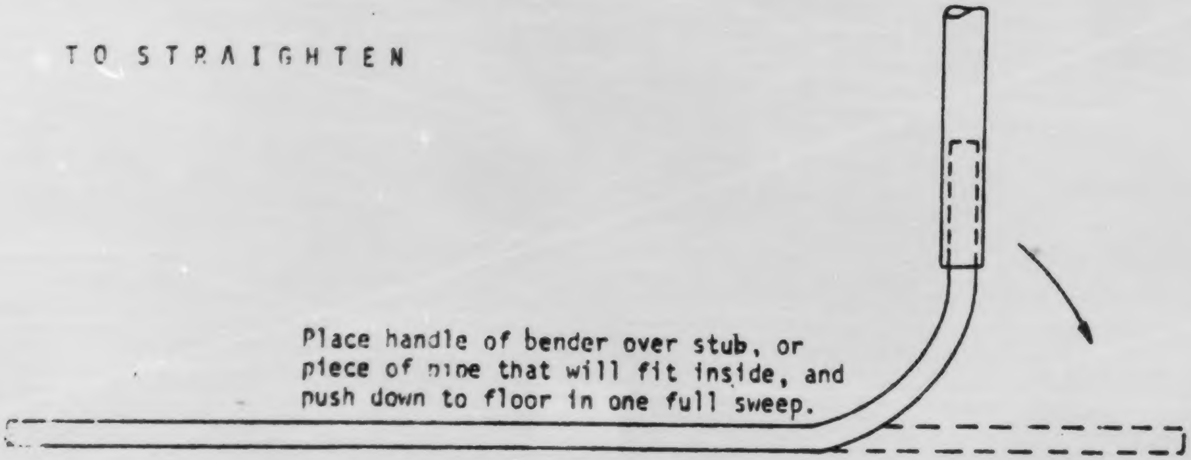
BACK-TO-BACK BENDS



Make stub bend at X with "Guide-Line" centered on either arrow located on side of hook. Measure distances from X to Y on tube.

Reverse bender and put A on bender at Y on tube. Line up "Guide-Line" with opposite arrow than used when making first stub and make second bend.

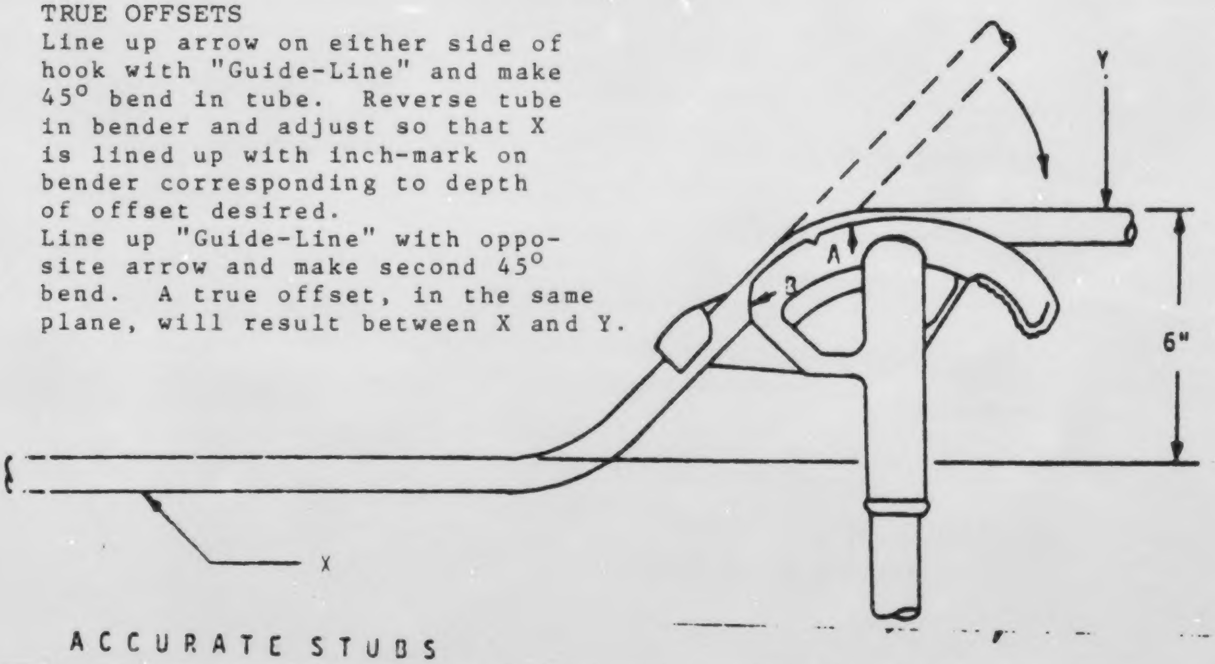
TO STRAIGHTEN



Place handle of bender over stub, or piece of pipe that will fit inside, and push down to floor in one full sweep.

TRUE OFFSETS

Line up arrow on either side of hook with "Guide-Line" and make 45° bend in tube. Reverse tube in bender and adjust so that X is lined up with inch-mark on bender corresponding to depth of offset desired. Line up "Guide-Line" with opposite arrow and make second 45° bend. A true offset, in the same plane, will result between X and Y.

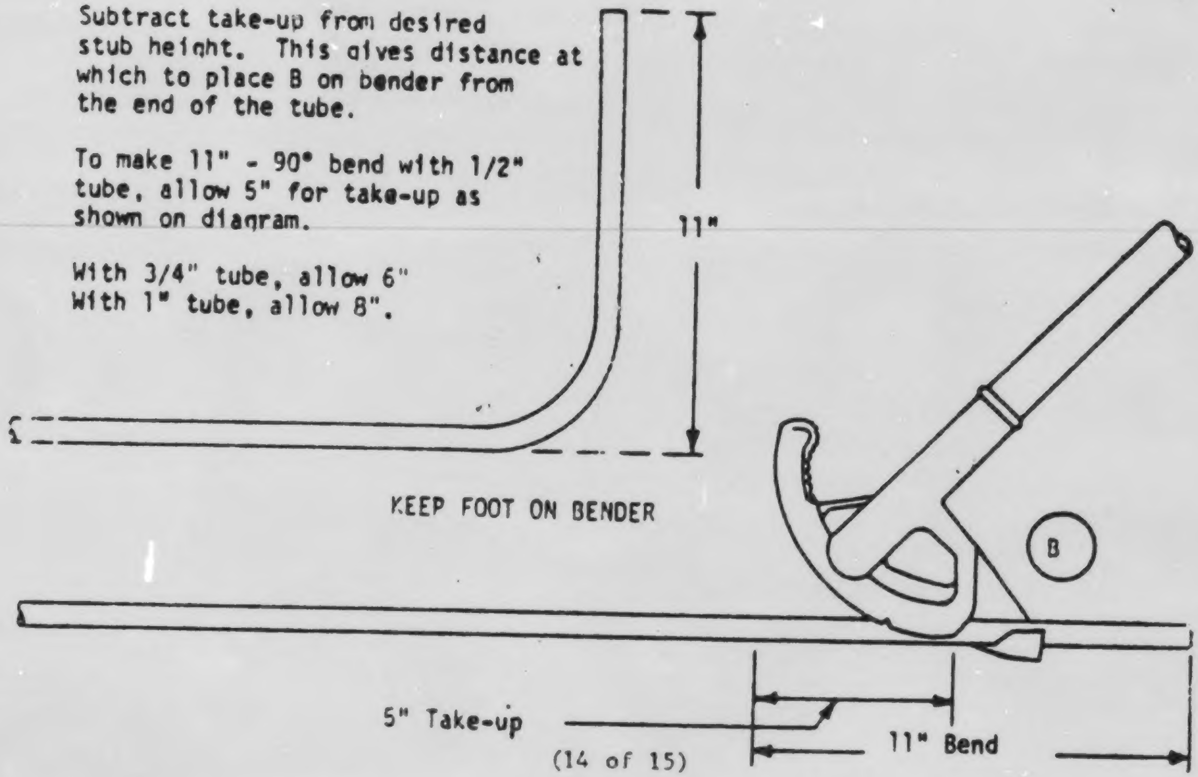


ACCURATE STUBS

Subtract take-up from desired stub height. This gives distance at which to place B on bender from the end of the tube.

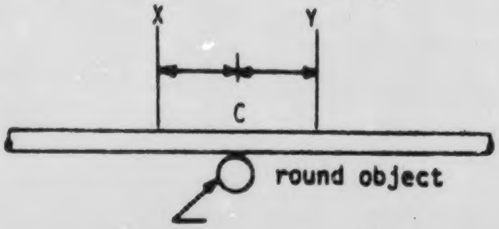
To make 11" - 90° bend with 1/2" tube, allow 5" for take-up as shown on diagram.

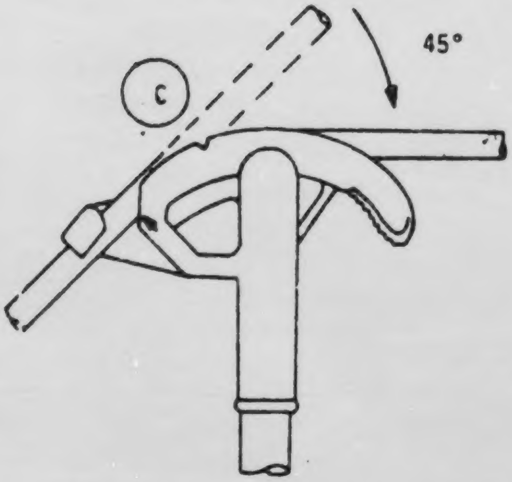
With 3/4" tube, allow 6"
With 1" tube, allow 8".



SADDLE BENDS

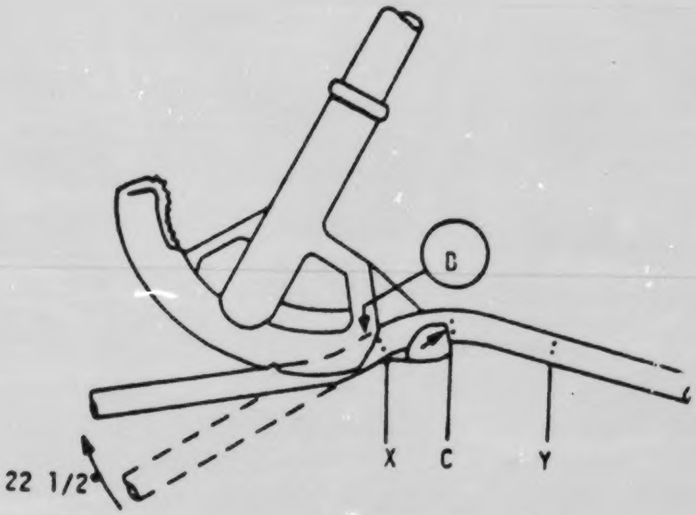
C-Center of finished saddle bend
X-Double the diameter of round object from C
Y-Double the diameter of round object from C

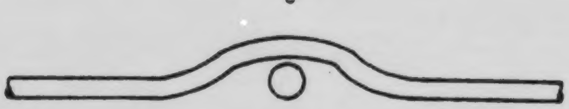




Place tube in bender so that C on tube is at notch on bender and make 45° bend. (A 45° bend is reached when bender handle is at a right angle to tube)

Reverse tube in bender and place B on bender at X on tube. Make return bend of 22 1/2°. Duplicate procedure placing B on bender at Y on tube and complete saddle my making another 22 1/2° bend.





Finished bend neatly saddles round object.

Proper alignment of the "Guide-Line" with arrows on bender hook will result in the saddle being in a straight line.

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CEA 1.3.~~14~~13.JS.1

CLASS: 2 PRACTICAL: 6

TITLE: MAINTENANCE AND TROUBLESHOOTING

INTRODUCTION: This job sheet will guide you in the procedures for maintaining and troubleshooting Circuits #1 - #4 completed in Topic CEA 1.3.13 "Cubicle Wiring".

MATERIALS: Electrician's tool kit, step ladder, wiping rags.

PROCEDURES: See Attached

QUESTIONS: Instructor prepared

REFERENCES: NAVFAC MO-116, "Facilities Engineering Electrical Interior Facilities", March 1972

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Maintain and test circuit breaker panel.	1a. Ensure that main breaker is in the Off position.	
	1b. Label all circuits with circuit number and type.	
	1c. Check interior of panel for cleanliness.	
	1d. With a screwdriver, check all circuit breaker load connections. "Do Not Over Tighten".	
	1e. Check load balance (equal distribution of load across the two phases).	1e. Calculate appros. load using the following factors: Receptacle - 180 watts Flourescent fixture - 100 watts 1 H.P. motor - 746 watts
	1f. Grounding: Check connections at panel and ground rod.	1f. Circuit breaker panel and grounding system maintenance and load balance. Steps of procedure shall be performed 100% correct.
2. Inspect conduit and cable wiring systems.	2a. Electrical metallic tubing: Check all connectors and couplings by hand. If loose, tighten with adjustable open-end wrench.	

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WHAT TO DO	HOW TO DO IT	KEY POINTS
	(1) Check securing of E.M.T. for proper number of bends, type of straps and their location.	
	2b. Flexible metallic conduit: Check all conduit connectors by hand. Remove any sharp edges at terminations.	
	(1) Check securing of flex for proper number of bends, type of straps and their location.	(1) Total number of bends shall not exceed 360°.
	2c. Non-metallic-sheathed cable: Ensure that all cable runs are run within the concealed areas of the building.	2c. Concealed areas: Within the stud and above the ceiling joists areas.
	(1) Check all cable connectors at the panel and junction boxes. "Do not over-tighten screws on cable connectors".	(1) Damage to cable insulation will occur when cable connector is secured too tight.
	(2) Ensure that the proper number of staples and their location were installed to secure the cables.	(2) Damage to cable insulation will occur when staples are hammered beyond the safe limit.
	Check for staples hammered too tightly on the cable.	Inspection of conduit and cable wiring systems shall be performed 100% correct.

WHAT TO DO	HOW TO DO IT	KEY POINTS
3. Maintain and test flourescent lighting circuit.	3a. Check fixture reflector for cleanliness. Clean if required.	
	3b. Check flourescent lamps for seating firmly and correctly in the lamp holders.	
	3c. Turn On lighting circuit breaker at panel.	
	3d. Test 3-way and 4-way switched for proper operation.	3d. If switches do not operate correctly, review the drawing titled "3 and 4-way circuit diagram" for Circuit #3.
	3e. Turn light ON: If lamp flickers, swirls or flutters, turn Off for a few minutes - then turn ON. Change lamps if flicker remains.	3e. If flickering lamp is not replaced, it may cause damage to the ballast.
4. Maintain and test motor, motor controller and push-button station.	4a. Ensure that the motor circuit disconnect (at the Panel) is in the Off position.	
	4b. Motor controller: Remove cover and check for dirt, pieces of copper wire, presence of moisture and loose connections.	4b. Clean out all loose particles and tighten any loose connections. "Do not over tighten".
	(1) Check the ampere rating of the thermal overload units and compare with the nameplate ampere rating on the motor.	(1) If the current ratings differ by 4 or more amps, report this to the instructor.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(2) Check contacts for making full contact. Push contact assembly with finger positioned below solenoid (coil).	(2) This check will also ensure free travel of contact assembly.
	(3) Cleaning contacts: Use extra fine sandpaper and remove high spots on contacts, if required. Do not use emery cloth!!	
	4c. Push-button station: Remove cover and check for loose connections and conductors interfering with the travel of moving parts.	4c. Operate Stop and Start buttons to ensure free travel of moving parts.
	4d. Replace covers on controller and push-button station. Place Circuit #4 (disconnect at panel) to the On position.	4d. Maintenance and testing procedures shall be performed 100% correct.
	Push Start button and check motor for proper operation.	
	4e. Motor does not operate:	
	(1) Turn circuit disconnect to Off position.	
	(2) Use step ladder to get in position to check the splices and motor connections in the attic area.	
	(3) Refer to the wiring diagram "Single-Phase Motor Controller Connections" and make corrections as required.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(4) Repeat starting procedures and check system for proper operation.	(4) Maintenance and testing procedures shall be performed 100% correct.

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CEA JS2.1.1.1

CLASS: 4 PRACTICAL: 3

TITLE: Tying Knots

INTRODUCTION: This job sheet will guide you in the proper technique for tying the timber-hitch, clove-hitch, half-hitch, bowling, and grunt's knot. Knots will be used when building the overhead distribution system.

TOOLS AND EQUIPMENT: 6-foot step-ladder
3-classroom mounted training poles

MATERIALS: 3-handlines (complete with 4-foot attaching lines)
24-pieces of 6-foot length ½" synthetic lines

PROCEDURES: See attached

QUESTIONS: Instructor prepared

REFERENCES:

A. NAVPERS 10636-G, CE 3&2, Chapter 9

B. TM5-680, Electrical Facilities, May 1946

C. Lineman's and Cableman's Handbook, 4th ed., Kurtz, McGraw-Hill Book Co., New York, N.Y.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Secure hand-line to top of pole with '4' attaching line.	1. Using timber hitch.	1. Check knot tying display for correct procedure.
	1a. Take bitter end around the pole (6" from the tope) and lay on top of secured end. Bring under secured end and spiral back upon itself approximately 4 times. While holding bitter end, apply pul on secured end and draw tight.	1a. Using steps of procedure performed by instructor.
		1b. Insure that snap-hook and D-ring are at the bottom of the hand-line.
2. Tie a clove-hitch and a half hitch on a crossarm.	2. Lay crossarm in a horizontal position on the ground with one end resting on toe of line-boot. Apply "clove-hitch" to elevated end of corssarm by making two overhand loops (close to the snap and ring assembly), pass second loop behind first, then install over end of crossarm. Tighten by pulling firmly on both ends.	2. Use of lineboot permits use of both hands for tying clove-hitch. Position clove-hitch 4" to 6" from end of crossarm.
	2a. Rest opposite end of crossarm on lineboot and apply a half-hitch by removing slack from line, make one overhand loop formed and placed over end of crossarm so that tension on running end will tighten loop around crossarm.	2a. Remove slack in line between clove to half-hitch, applying half-hitch 4" to 6" of end of crossarm. If loop does not tighten on crossarm, reverse method of placing loop.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	2b. Test knots by raising crossarm with operating side of hand-line.	2b. If 100% correct in tying clove and half-hitch, lower and remove crossarm before performing bowline steps of procedure.
3. Tie a bowline in a 6 foot length of ½" practice line.	3. Form bowline in accordance with the following sketches: (Use sketch on page 41-6 L&C Hand Book)	3. Bowline will be used in pole top rescue. This type of knot is a non-slip, safe-to-use knot for lowering an injured lineman.
	3a. Have instructor check bowline for accuracy.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
4. Tie a Grunt's knot in a handline (Handline will be secured to the top of classromm practice pole) 704	4. Form the grunt's knot in accordance with the following sketches: 4a. Instructor will check Grunt's knot for accuracy.	4. A Grunt's knot is used to raise tools and fittings to the lineman on the pole. 705

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CEA 2.1.2.JS.1

CLASS: 1 PRACTICAL: 5

TITLE: Framing Poles

INTRODUCTION: This job sheet will provide you with terms and their definitions. The terms listed will acquaint you with the three tasks outlined in the topic objective and the proper steps of procedures you will follow to successfully complete them.

TOOLS & EQUIPMENT: 6'-folding rule, framing square (36" X 24", two cant hooks, buck-saw, lineman's hammer or wood mallet, chisel (2" wood), wood brace, 11/16" x 14" auger-bit, framing rack.

MATERIALS: 1-untreated power pole.

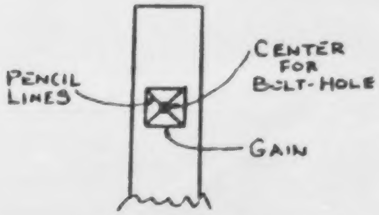
PROCEDURES: See Attached

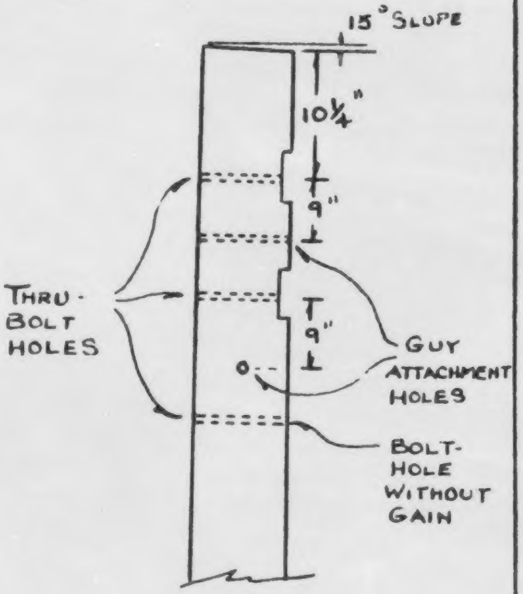
QUESTIONS: Instructor Prepared

REFERENCES: Lineman's and Cableman's Handbook, 4th ed., Kurtz, McGraw - Hill Book Co., N.Y., N.Y.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Identify terms used in "framing" a pole.	1. Terms and definitions:	
	a. roof - top of pole angle cut 15°, face-to-back.	
	b. Butt - bottom of pole.	
	c. Face - inside curve of pole.	
	d. Back or High side - outside curve of pole; side used for climbing.	
	e. Gain - a flat surface cut into face side of pole for mounting crossarms.	e. Exception: For special application other than a straight run, the gain may be cut where required for take-off crossarm.
	f. Gain (preformed) - for attaching crossarm without use of cut-in gain.	
	g. Thru-bolt hole - Required for mounting crossarms.	
	h. Guy attachment hole - Required for guy attachments.	
	i. Framing-rack - supports for both ends of pole for framing tasks.	
2. Position pole for framing.	2. Position pole on "framing-rack" with face up.	2. Use of two cant hooks by one student to position and hold the pole while framing.

WHAT TO DO	HOW TO DO IT	KEY POINTS
3. Roofing the pole.	3. Rotate pole 90°.	3. Student with cant hooks will rotate pole 90° for purpose of measuring and cutting roof.
	3a. On back side-measure from the top down 1" and mark with chalk or pencil. Complete angle of 15° cut by scribing line from top of face to mark on back side.	3a. Utilize framing square (36" x 24") guide for pencil to complete line for roof cut.
	3b. Use buck-saw to follow guide line in cutting roof.	3b. While cutting, maintain true vertical axis in downward strokes. Upon completion of cut, reposition pole to "face up" position.
4. Cutting a single gain.	4. On the face of the pole measure down from the roof 1p¼" and mark with pencil.	4. Note in movie how centerline of pole is found.
	4a. Measure 2¼" above and below 10¼" guide mark and make two horizontal lines for top and bottom of gain.	4a. Height of crossarm determines size of gain. Standard arm height - 4½".
	4b. Using buck-saw, cut along the two lines ½" to 5/8" deep.	4b. Maintain accurate horizontal position of saw while cutting.
	4c. With a lineman's hammer and wood chisel (2" width) split the gain in two equal vertical halves.	4c. Do not drive chisel deeper then the saw cuts.
	4d. From outside to center drive chisel and remove ½ of the gain at a time.	4d. Remove small amounts during this step and insure that finished gain is concave.

WHAT TO DO	HOW TO DO IT	KEY POINTS
5. Cutting multiple gains.	5. On the face of the pole in accordance with the special application situation given by the following drawing: CEA 2.1.7.D.1 "Transformers and secondary distribution pole".	5. Measurements shall be given by the instructor for the voltage involved.
6. Boring holes.	6. Position for boring holes shall be found by drawing two diagonal pencil lines that intersect in the center of each gain as per sketch:  	6. Eventual mounting of crossarm depends upon accuracy of the location of the bolt-hole. Hole position shall be within + or - 1/8".
	6a. Follow steps of procedure aligning gains outlined in L & C Handbook, page 10-10.	
	6b. With a wood brace and a 11/16" x 14" auger-bit bore hole at the center of each gain.	6b. Maintain a vertical position on the auger while drilling by having a student check to insure accuracy.
7. Check framing with the instructor.	7. Template as indicated in L & C Handbook, page 10-10 will be used to check for accuracy of alignment and depth of the 2 gains and 3 holes.	7. The template shall have ¼" clearance at top & bottom of each gain.
	7a. Roof angle will be checked with an adjustable angle square.	7a. The roof angle may have a + or - 1° variation from the required 1

WHAT TO DO	HOW TO DO IT	KEY POINTS
8. Anchor guy thru-bolt holes.	8. Thru-bolt holes for guy attachments will be located (in line with) gain thru bolt holes. Measure down from center of top gain thru bolt hole 9". Second anchor guy thru-bolt hole will be located 9" down from center of middle-gain hole and 90° from center line in accordance with the following sketch:  15° SLOPE 10¼" 9" 9" THRU-BOLT HOLES GUY ATTACHMENT HOLES BOLT-HOLE WITHOUT GAIN	8. Top guy attachment hole for primary line anchor and second hole for secondary distribution guying at 90° from primary. All holes shall be within + or - 1/8".

NAVAL SCHOOLS CONSTRUCTION
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CEA 2.1.3.JS.1

CLASS: 2 PRACTICAL: 7

TITLE: Erecting and Setting Poles

INTRODUCTION: The steps of procedure for manually erecting and setting a 35-foot pole are outlined in this job sheet for use by a team of ten men. This pole will become part of the power distribution line to be built.

TOOLS & EQUIPMENT: Digging bar, short "D" handled shovel, straight shovel, spoon shovel, tamping bar, pike poles, cant hooks, jenny or mule, carrying hooks, sighting rod.

MATERIALS: 1 - 35 foot pole
1 - butt board, 2" x 12" x 8'

PROCEDURES: See Attached

QUESTIONS: Instructor prepared

REFERENCES: A. NAVPERS 10636-G, CE 3&2, Chapter 9

B. Lineman's and Cableman's Handbook, 4th ed., Kurtz, McGraw-Hill Book Co., N.Y., N.Y.

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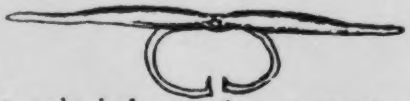
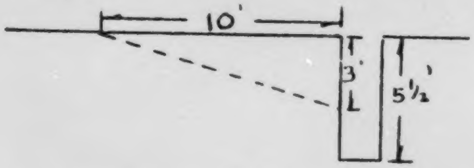
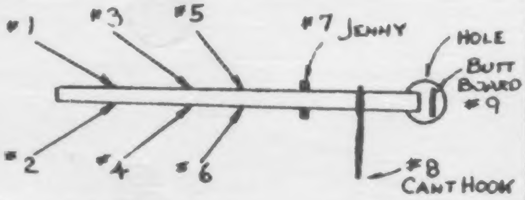
WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Identify terms used in "Setting a pole".	1. Terms and definitions: a. Pole hole - Hole in soil of a specific depth and diameter. b. Pole hole diameter - should be at least 6" greater than the diameter of the pole at the butt. c. Pole hole depth - Determined by the length of pole and the type soil: (1) Normal soil: 10% of the pole length and add 2 feet, min. of 5 feet. example 40' pole: 10% of 40 = 4 feet + 2 feet = 6 feet. d. Digging Bar - approximately 6 feet long, one end shaped to a blunt chisel point, other end shaped to a point similar to a pencil. e. Shovels: (1) Short "D" handled shovel- used in digging first few feet of pole hole. (2) Straight shovel - used to cut sides of holes straight down and to loosen dirt at bottom of hole. (3) Spoon shovel - used to lift loose ground from bottom of hole.	1. Refer to Lineman's and Cable

WHAT TO DO	HOW TO DO IT	KEY POINTS
	f. Tamping bar - wood or steel bar approximately 6' long used to compress all the ground taken out of the hole back down around the pole.	
	g. Pike pole - approximately 16' with a steel point on one end. Used by piking crew to raise pole and steady the pole during tamping operation.	g. Refer to L & C Handbook pages11-9 for table 11-2, "Average size of crew required to raise poles of different lengths".
	h. Cant hook - a movable hook on a 4' handle used to keep pole from rolling and to turn the pole when required.	
	i. Jenny or mule - pole support approx. 6' high used to support pole during lifting operation.	
	j. Butt board - 2" x 12" x 8' board used as backing board while setting pole in hole.	
	k. Carrying hooks - double handled hooks for carrying poles by hand. 	
2. Dig pole hole.	2. Dig pole hole to the required width and depth for a 35' pole in accordance with "Pole hole diameter and depth" definitions.	2. Refer to L & C Handbook, pages 11-4 to 11-6.

WHAT TO DO	HOW TO DO IT	KEY POINTS
3. Dig trench to pole hole.	3. Dig trench to easily accomodate the width of the pole, and in accordance with the following sketch:  	3. Ditch and hole measurements shall be within + or - 6 inches.
4. Set pole in hole.	4. Assign numbers 1010 to piking crew and crew leader: a. #1-6 "Pikers" b. #7 "Jenny" operator c. #8 "Cant hook" operator d. #9 "Butt board" man e. #10 "Crew leader".	4. Refer to L & C Handbook, pages 11-9 to 11-12.
	4a. #9 - position butt-board in hole.	
	4b. #10 - issue command to #1-6 to position pole in trench with butt of pole against buttboard.	4b. #1-6 will use 3 carrying hooks to place pole in ditch.
	4c. #10 - issue command to #1-6 to raise end of pole by hand, and #7 to place "Jenny" under the pole for support.	
	4d. #10 - issue command to #1-6 to position pikes in accordance with the following sketch. SEE PAGE (5 OF 6)	4d. All commands shall be executed 100% correct

WHAT TO DO	HOW TO DO IT	KEY POINTS
	 #1 #3 #5 #7 JENNY HOLE BUTT BOARD #9 #2 #4 #6 #8 CANT HOOK	
	4e. Raise pole upon command until rear pikers #1 and 2 yell "high pike". Stop raising pole and allow #7 to move forward with Jenny under pole.	4e. Piking procedures shall be executed 100% correct.
	4f. With Jenny repositioned #1 and 2 will re-pike their poles in front of #5 and #6 (one at a time) #10 will then comman to raise pole until "high pike" is yelled again, followed by above routine until pole settles in hole.	4f. #8 will reposition cant hooks as pole decends further into the hole. Operator will keep the pole from turning. #9 - make sure butt-board does not bind the pole by becoming cocked in the hole.
	4g. Align pole with pikers #1 - #4 positioned 90^o around the pole.	
	4h. #9 - remove butt board.	
	4i. #10 will align the pole by informing #8 to turn pole so that the gains face the direction outlined in the blueprint NAVFAC DWG No. 1109831. NEXT STEP: #9 and #10 will use a pike pole held vertically with point in the ground positioned approx. 30' from pole so that alignment can be determined from 2 positions 90^o apart.	4i. Refer to L & C Handbook, page 11-23.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	4j. #1-4 will set bottom of pike poles firmly on the ground and hold steady until back fill is completed.	
5. Back fill and tamp dirt in hole around pole.	5. #9 will shovel dirt into hole, and #5-6 will tamp the dirt so that all that has been taken out is compressed around the pole.	5. Remove aligning pikers (#1-4) when enough earth has been back filled to support the pole. (approx ½ way up the hole) ALL the dirt taken out of the hole shall go back in the hole.
		5a. Vertical position of pole and gain direction shall be 100% correct.

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CEA 2.1.4.JS.1

CLASS: 2 PRACTICAL: 14

TITLE: Mounting Crossarms, Pins and Insulators

INTROCUTION: This job sheet in conjunction with the NAVFAC drawing No. 1109831 "Advanced Base Standard Pole Line, No.2 AWG Conductors, 2400/4160, 3 Ph, 4 wire", will guide you in mounting crossarms, pins and insulators. The steps of procedure shall be closely coordinated with the various crossarm configurations as outlined in the drawing.

TOOLS & EQUIPMENT: Lineman's tool kit, climbing gear, hard hat, handline, auger truck, line truck.

MATERIALS: As listed in NAVFAC DWG No. 1109831

PROCEDURES: See attached procedures and drawing

QUESTIONS: Instructor prepared

REFERENCES: A. NAVPERS 10636-G, CE 3&2, Chapter 9

B. Lineman's and Cableman's Handbook, 4th ed., Kurtz, Mcgraw-Hill Book Co., N.Y., N.Y.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Identify terms used in mounting crossarms, pins and insulators.	1. Terms and definitions:	
	a. Single crossarm- support for insulators and conductors. Used on straight line runs where there is no excessive strain. Also used as bottom support for transformers.	a. Refer to L & C Handbook, pages 13-1 to 13-10 alternate arms in a straight tun should face in the same direction.
	b. Double arm-Used at line terminals, corners, angles, or at other points where there is an excessive strain.s When two or more transformers are mounted on the same pole, double arms are used for their support.	
	c. Buck or reverse arms-used at corners and at points where branch circuits are taken off at right angles to the main line.	
	d. Side arms-used in alleys or other locations where it is necessary to clear buildings.	
	e. Pin holes-are located on crossarms at various distances determined by the distribution voltage and number of phases.	
	f. Insulator pins-installed in pin holes for support of insulators.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	g. D.A. Bolt - double arming bolt - used when assembling two arms on a pole. h. Thru-bolt - used to mount crossarm on pole. i. Carriage bolt - used to attach the crossarm braces to crossarm. j. Eye bolt - Use similar to D. A. bolt with additional function of mounting suspension insulators. k. Lag screw - used to attach crossarm brace to pole. l. Braces - (1) Flat - used to prevent crossarm movement on pole. (2) Angle - used to prevent crossarm movement where line goes off on an angle. m. Insulators- (1) Line - used to support primary conductors on top of crossarms. (2) Suspension- used to dead-end primary conductors on any part of pole line requiring a change of direction.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	n. Spring washers - used to eliminate loosening condition created by thermal expansion and contraction of nuts, bolts, and pins.	
2 Mounting crossarms and pins on a pole in a horizontal position on the ground. (corner pole)	2. Support the top end of the pole approximately 4½ feet off the ground by use of the line truck. Apply the hook and cable near the mid-point of the pole and hoist top end to the required distance.	2. Pole hole to be dug by auger truck.
	2a. Mount the crossarms pins and associated hardware in accordance with NAVFAC drawing No. 1109831 "Advanced base standard pole line, No. 2, AWG conductors, 2400/4160, 3Ph, 4 wire", Section "Crossarm Construction 61°-90° angle.	2a. All hardware items are listed in the bill of materials and each item can be located by their assigned number installation of crossarms pins and associated hardware shall be 100% correct in accordance with the drawing.
3. Install corner pole in hole.	3. Use line truck and required line handlers to position pole in hole.	
	3a. Shoveler and tampers secure pole in hole.	
4. Mounting single crossarms and pins on a pole in a vertical position in the ground.	4. Prepare crossarms on the ground in accordance with the position of the pole in the pole line and the applicable detail drawing as per NAVFAC drawing No. 1109831.	4. Carefully note each type of cross-arm configuration, and how they vary in the types of hardware required.
	4a. Prepare to mount crossarms with lineman up on pole facing gain side of pole and secure a handline with a timber hitch above top gain.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	4b. Groundman: Using handline with snap and ring at bottom of loop tie a clove-hitch on lower end of crossarm and half-hitch on the other end.	4b. Ensure that braces are next to pole, and top of crossarm will be up when lineman receives the assembly from the handline.
	4c. Lineman: When receiving crossarm, remove half-hitch from upper end and lay arm across safety belt with assistance from groundman.	4c. Groundman will help raise the crossarm on the lineman's belt after the half-hitch has been removed.
	(1) With arm approximately at same level with gain while resting on safety strap, the lineman will slide the thru-bolt into the gain-thru-hole while pushing bolt from other side of arm.	(1) Lineman: Do not remove clove-hitch until thru-bolt is secured with nut on spring washer.
	(2) Place spring washer and nut on thru-bolt. Use lineman's wrench to tighten nut until spring washer is fully compressed.	(2) Refer to print "Bill of material" for specific type of hardware required on each crossarm configuration
5. Mounting double crossarms, pins and associated hardware on a set pole.	5. Prepare double crossarms on the ground as per item #4.	
	5a. First lineman - ascend pole and secure handline above top gain and position safety belt even with bottom of top gain.	
	5b. Second lineman - will be positioned on opposite side of pole.	5b. Second lineman will not ascend pole until the first lineman is set in his working position.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	5c. Groundman - raise crossarm with D.A. bolts and thru-bolt in similar manner as item 4b and c. First lineman facing gain will receive this crossarm.	
	5d. First lineman - position first crossarm on safety belt and guide thru-bolt into gain hole. Apply pressure on thru-bolt until thru the pole and hold for positioning of second crossarm.	
	5e. Second lineman - call for second crossarm. Position arm on safety belt and guide onto first arm D.A. bolts and thru-bolt.	
	(1) Place spring washer and nut on thru-bolt first - tighten until washer is fully compressed. Repeat same on D.A. bolts.	
	(2) Apply dead-ending insulators and hardware as per drawing.	(2) First lineman shall assist second lineman in receiving dead-ending hardware from ground.
	5f. Secure crossarm assembly.	5f. Installation shall be level and facing in the proper direction. All nuts, bolts and screws will be tight.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	5f. (cont'd) (1) level crossarms (2) Position braces to center of pole. (3) Drive lag screw to ¼" of tight position. (4) Complete tight-ending of screw with lag wrench.	
6. Inform instructor that crossarm installation is complete.		

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CEA 2.1.5.JS.1

CLASS: 1 PRACTICAL: 7

TITLE: Guying poles

INTRODUCTION: This job sheet will guide you in the proper steps of procedure for assembling and installing a guy and anchor. Type of guy will be dependent upon its location in the pole line and the material required. Installation will be in accordance with the NAVFAC DWG No. 1109831 - "Advanced Base Standard Pole Line, No. 2 AWG Conductors, 2400/4160, 3 Ph, 4 wire.

TOOLS & EQUIPMENT: Lineman's climbing gear, tool kit, auger truck, shovel, tamping bar, cable grip, coffin hoist, strand vise hook.

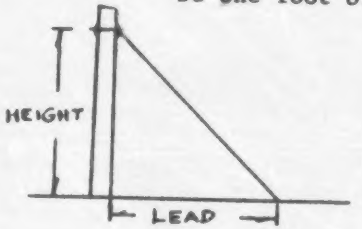
MATERIALS: Through-bolts, guy attachments, preformed guy grips, strain insulators, strand vise, expanding type anchor and rod.

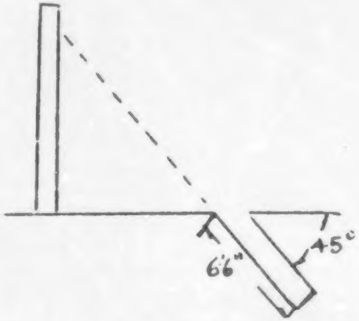
PROCEDURES: See attached

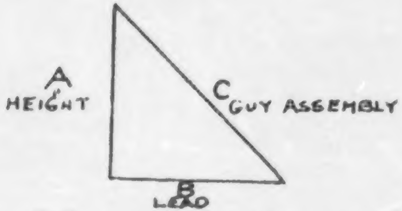
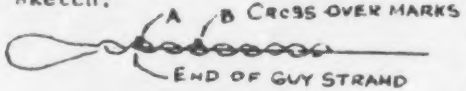
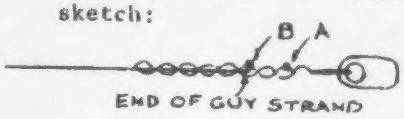
QUESTIONS: Instructor prepared

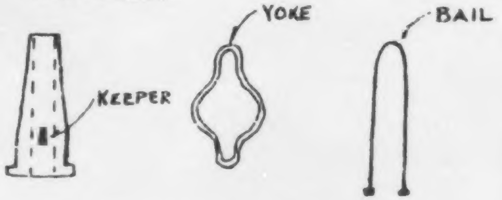
REFERENCES: A. NAVPERS 10636-G, CE 3 & 2, Chapter 9

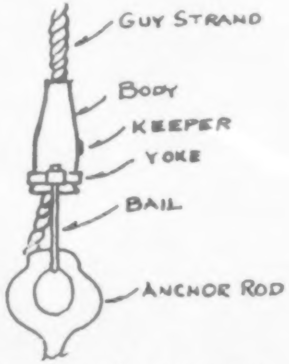
B. Lineman's and Cableman's Handbook, 4th Ed., Kurtz, Mcgraw-Hill Book Co., N.Y.,N.Y.

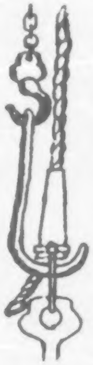
WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Digging in the anchor.	1. For each type of guy to be installed, refer to NAVFAC drawing No. 1109831 "Advanced Base Standard Poleline, No. 2 AWG Conductors, 2400/4160, 3 Ph, 4 Wire", for applicable measurements and guy ratio $\frac{\text{Height}}{\text{Lead}}$. Ideal Ratio: For every foot of height there should be one foot of lead.  	
	1a. Locate hole by refering to drawing for direction and 2 to 1 ratio.	
	1b. Hole to be dug on a 45° angle away from the pole. Auger truck will be operated by instructor.	1b. Depth of hole dependent upon length of anchor rod. Example: 5/8" x 7'. Eye of anchor rod shall be approx. 6" above ground. Depth of hole 6'6".

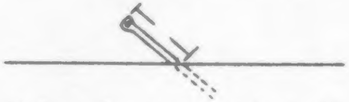
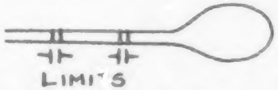
WHAT TO DO	HOW TO DO IT	KEY POINTS
	1b. (cont'd)  	
	1c. Install expanding type anchor and back-fill anchor hole, with shoveling and tamping procedures used in filling pole holes.	1c. Installation procedures as per classroom instruction and film presentation. Ensure that opening of anchor eye opening is facing ground.
2. Install "Malleable guy attachment" on pole.	2. Select thru-bolt with length required for diameter of pole and guy attachment. Installation will be in accordance with the guying detail in NAVFAC DWG # 1109831.	
	2a. Lineman-Install guy attachment on pole 9" below top crossarm and 9" below 2nd crossarm. Use holes drilled during framing practical. Number of guy attachments dependent upon location of guying and guying detail description outlined in NAVFAC DWG # 1109831.	2a. Check guy detail for required hardware to secure guy.

WHAT TO DO	**HOW TO DO IT**	**KEY POINTS**
3. Assemble "Guy Assembly" on the ground.	3. Calculate overall length of guy assembly using Pythagoreum Theorum $C^2 = A^2 + B^2$ or $C = A^2 + B^2$  	
	3a. Use "C" measurement for length of guy wire. Cut required length and cut piece in half.	3a. When length of guy wire is cut in half, location of strain insulator is established in the middle of the guy assembly.
	3b. Install "Preformed guy grip" on the top section of guy strand in accordance with the following sketch:  Long leg of guy grip shall be applied first to its entire length. Align cross-over mark "A" of short leg with "A" mark on long leg. Complete installation.	3b. Cross-over marks "A": to be used as strand starting point for small hardware and anchor rods. Cross-over marks "B": (provided only on sizes 3/8" and smaller): to be used as strand starting point for insulators requiring a larger loop.
	3c. Install next "Preformed guy grip" on the other end of the top section of the guy strand in accordance with the following sketch:  	3c. Ensure that "frost ring" of strain insulator will be pointing down when installed.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	3c. (cont'd) Apply long leg of guy grip starting at mark "B". Complete installation as per 3b., except align mark "B" of short leg with "B" of long leg.	
	3d. Install bottom section of guy strand to strain insulator and complete guy grip installation as per 3c.	3d. Have instructor check completed guy assembly before proceding to next step.
4. Install "Automatic dead-end strand vise" on anchor rod.	4. Disassemble strand-vise by removing body from yoke, and separate yoke from bail: 	
	4a. Insert bail into eye of anchor rod and reassemble strand vise.	4a. Final assembly should have keeper 90° from bail.
5. Attach "Guy assembly" to pole.	5. Lineman - ascend pole and belt off close to guy attachment. Receive guy assembly via handline.	5. Grunt: Use "Grunts" knot in eye of top preformed guy grip.
	5a. Grasp guy assembly with both hands approx 4 to 6" below the preformed eye and inform the grunt, to release the grunts knot by pulling ob the handline.	
	5b. Place eye of guy grip over the guy attachment.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	5c. Descend pole.	5c. Grunt - keep guy assembly away from pole while lineman descends pole.
6. Attach "Guy assembly" to anchor rod.	6. Insert "Guy Strand" through body of "Strand vise" in accordance with the following sketch: 	6. Remove slack from guy strand by holding strand vise with one hand and pull on guy strand with other hand. Ensure that strand is straight (free of curve due to strand reel) and end unfrayed.
	6a. Attach "wire grip" (with eye down) approx. 4 feet from strand vise.	
	6b. Insert top hook of coffin hoist into eye of wire grip.	5b. Ensure that free chain with bottom hook is extended to within 4-6 inches of maximum.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	6c. Insert bottom of hook of coffin hoist to eye of strand vise pulling hook in accordance with sketch: 	6c. Remove slack from coffin hoist chain.
7. Tensioning guy assembly.	7. Operate handle assembly of coffin hoist through its maximum up and down travel.	7. Assistant to coffin hoist operators will guide guy strand into strand vise as tensioning is performed.
	7a. Observer positioned 90° from guy assembly axis, and approx. 30 feet from pole, will inform doffin hoist operator when the top of pole is pulled 4 to 6" from dead center.	
	7b. Place coffin hoist control lever in the "down" position, operate handle as per #7, remove coffin hoist and pulling hook when adequate slack is in the chain.	7b. Place coffin hoist where sand or dirt will not enter working parts.

WHAT TO DO	HOW TO DO IT	KEY POINTS
8. Remove excess guy strand.	8. Cut end of guy strand with bolt cutters to within 1 to 3 inches of strand vise body.	8. Guy installation shall be within the following tolerances: a. Eye of anchor rod: 6 to 12 inches above ground.  b. Ends of guy strand shall be within the limits of appropriate cross-over marks.  c. Strain insulator: Frost ring-towards ground. Min. clearances: Horizontal - from face of pole - 6 feet. Vertical - from finished grade - 8 feet. d. End of strand: 1 to 3 inches past strand vise body.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CONSTRUCTION ELECTRICIAN "A" SCHOOL TRAINING COURSE A-721-0018

JOB SHEET

TITLE: Stringing Primary Line Conductors

INTRODUCTION: This job sheet will guide you in the proper procedures for installing the primary line conductors.

REFERENCES:

1. Construction Electrician 3 & 2, NAVPERS 10636-G, chapter 9.
2. Lineman's and Cableman's Handbook, 4th edition, Kurtz, McGraw-Hill Book Co., New York, N.Y.

TOOLS, EQUIPMENT AND MATERIALS:

1. Lineman's tool kit.
2. Climbing gear.
3. Hard hat.
4. Handline.
5. Slings.
6. Cable grips.
7. Coffin hoists.
8. Other materials as listed in NAVFAC Drawing No. 1109831.

PROCEDURES:

1. Installation of primary conductors.
    a. Select the pre-determined lengths of #6 AWG medium hard-drawn solid copper conductors (identified coils).
    b. Lay out conductor coils by rolling alongside of poles from dead-end poles. Leave 6 feet past both dead-end poles.
        (1) Conductors will be positioned on the ground under related insulators on the poles.
    c. Lineman: Ascend dead-end pole with handline and prepare to receive primary conductors.

d. Groundman: Secure a wire grip jaw to end of one conductor and secure wire grip to snap of handline. Raise wire grip and conductor to lineman.

  (1) Secure conductor in jaw assembly of wire grip approximately 6 feet from end. Raise inside conductors first.

e. Lineman: Insert end of #6 conductor into auto. dead-end assembly. Pull in approximately 6 feet. Repeat same procedures for the remaining three conductors.

f. Lineman: Descend dead-end pole and ascend the first pole in line (with handline).

g. Groundman: Place hook of handline on one inside conductor. Raise conductor to the lineman. Repeat with other inside conductor.

h. Lineman: Place inside conductors on the inside of the center insulators.

  (1) Inside of insulators- side of insulators facing the pole.

i. Lineman: Place remaining conductors on the inside on their respective insulators.

j. Complete raising of conductors on the remaining in-line poles.

k. Linemen (two): Ascend corner pole with a handline and prepare to raise and secure primary conductor ends.

l. Groundman: Secure a wire grip to the end of one outside conductor and secure other end of wire grip to the snap of handline.

  (1) Secure conductor in jaw assembly of wire grip approximately 3 to 6 feet from end of conductor. Raise outside conductors first before raising center conductor.

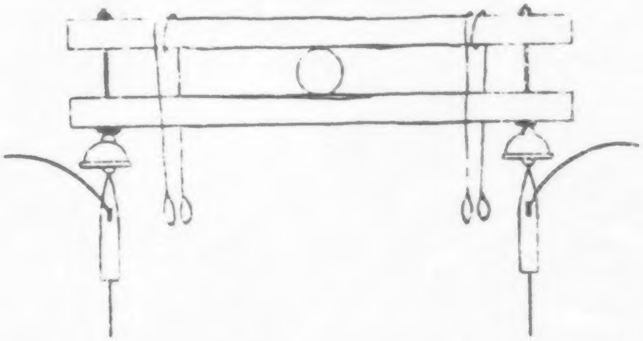
m. Lineman: Insert end of each conductor into auto. dead-end assembly. Pull in approximately 4 feet. Repeat same procedures for all conductors.

2. Sagging primary conductors.

  a. Groundman: Select two (2) 4 foot slings (3/8" stranded steel cable with a standard six eye at each end) and hoist to the lineman.

    (1) Select two (2) "coffin hoists" of the same size and hoist to the lineman.

b. Lineman: Secure slings as per sketch:



(1) Insert hook of each coffin hoist into eye's of slings and secure chain-end hook into cable-grip attached to each outside conductor.

(2) Operate handles of coffin hoists until correct sag is obtained.

(a) Sag will be determined by instructor sighting from the ground.

c. During sagging procedure, ensure that each conductor is guided (without kinking) through the auto. dead-end.

(1) Conductor should be coming out of the top or bottom of the auto. dead-end in accordance with drawing.

d. After proper sag is obtained on the outer conductors, remove one set of sagging equipment and install on inside conductors.

e. Perform same sagging procedures as outlined in 2b and sag to same configuration as the outside conductors.

f. Remove equipment after all conductors have been raised and sagged.

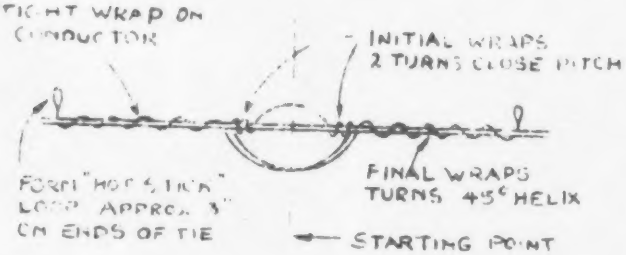
3. Secure primary conductors to pin insulators. (Make ties.)

a. On all in-line poles, conductors will be placed on top of each respective insulator.

b. Groundman: Select (for each pole) 4 pieces of 36 inch long, #6 AWG soft-drawn, solid copper conductor.

(1) Utilize nose-bag for hoisting tie-wires to lineman.

c. Lineman: Follow sketch:


TIGHT WRAP ON CONDUCTOR
INITIAL WRAPS 2 TURNS CLOSE PITCH
FORM "HOT STICK" LOOP APPROX 3" ON ENDS OF TIE
FINAL WRAPS TURNS 45° HELIX
STARTING POINT

Single-pin type insulator tie for copper con

(1) Practice tie on classroom training aid b ties on s
overhead conductors.

(a) Complete ties on all in-line poles.

4. Make jumber connections at all corner poles.

a. Groundman: Compile a list of material requir e in
accordance with the NAVFAC DWG #1109831, "Adv ndard Pole
Line".

(1) Ensure that the required number of split- rs and
and jumper wires are on hand before linem e corner
poles.

b. Lineman: Ascend corner pole and complete the of
primary conductors in accordance with the draw

(1) Form the jumper wires in a smooth and safe configuration between conductors. Primary conductors shall be installed and sagged with appropriate ties made on each insulator. All work shall be executed 100% correct.

NAVAL SCHOOLS CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043

CE"A" 2.1.7 JS 1
CLASS; 3 PRACTICAL; 7

TITLE; TRANSFORMERS AND PROTECTIVE EQUIPMENT

Introduction; This job sheet will guide you in the proper procedures to install the secondary transformers and pr tective equipment.

Tools, and Equipment; Lineman's Tool Kit, climbing gear, harhat, handline, transformers, protective equipment.

Materials; As listed in NAVFAC DWG No 1109831

Procedures; See attached procedures

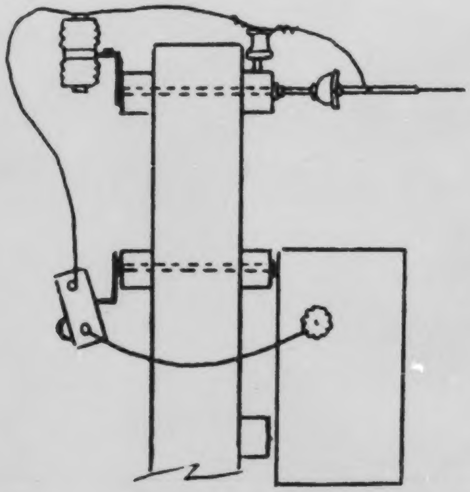
Questions; Instructor prepared

References; A. NAVPERS 10636-G, CE 3 & 2, Chapter 9. .

B. Lineman's And Cableman's Handbook, 4th ED, Kurtz, McGraw-Hill Book CO, N.Y., N. Y.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Preparing for installing transformers.	1a. Lineman #1: Ascend transformer pole with handline and prepare to receive the pole top gin.	
	1b. Lineman #2: Ascend pole and position on opposite side of Lineman #1.	
	1c. Groundman: Attach pole to top gin to handline using a "Grunts" knot somewhere near and above the snap and ring. Hoist to lineman	
	1d. Lineman #1: Position pole top gin.	
	1e. Secure pole top gin in accordance with instructor's classroom demonstration.	
	1f. Groundman: Select a blockand tackle assembly and use handline to hoist gear to Lineman #1.	1f. Ensure that one person holds bott portion of the block and tackle while Groundman hoists assembly to Lineman #1.
	1g. Lineman #1: Recieve hook of block and insert into eye of poletop gin.	
	1h. Groundman: Position transformer directly below block and tackle assembly.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
2. Install transformers to step down three-phase, 4-wire, 4160V.	2a. The following procedures will be used for the installation of three single-phase transformers:	
	2b. Groundman: Attach tag line around main body of transformer with a timber hitch.	
	2c. Groundman: Attach a 30-inch sling (with an eye on each end) to the lifting hooks on the sides of the transformer. insert hook of block and tackle on to sling	2c. Line handler will take up the slack on the block and tackle assembly as soon as hook is engaged in the sling secured to the transformer.
	2d. Four (4) Men: Two men on the tag line and two on the fall line of the block and tackle assembly	2d. "Fall Line" is the hoisting line coming from the top block.
	2e. While two men raise the transformer the handlers tending the tag line will ensure that the transformer is kept away from the pole	
	2f. Lineman: With appropriate signals, indicate to the groundmen the exact height required for the transformer to be before placing on crossarms.	2f. First two transformers will be placed on the outside of the crossarms. Third transformer will be centered on crossarms.
	2g. Lineman: After each transformer is placed in position; remove tag line and secure end to eyes of sling(while still secured to block and tackle).	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	2h. Groundman: Lower bottom block by pulling on tag line.	
	2i. Complete transformer installation using procedures outlined above	2i. Position transformers with equal spacing on the crossarms.
	2j Lineman #1&#2: Lower block and tackle with handline. Disassemble pole top gin from pole, and also lower with handline	2j Transformer installation procedur shall be executed 100% correct
3. Install protective equipment.	3a. Groundman: Select 3-fused cutouts and 3-lighting arrestors, also 6-"L" type brackets for mounting the protective devices. Hoist material to lineman with associated hardware for mounting and securing devices	
	3b. Lineman: Install brackets as per sketch: 	3b. Outer fused cutouts shall be installed at a slight angle in towa the pole. (Required for operation of hot stick to open fused cutout

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(1) Mount the arrestors first, then reposition on pole to mount fused cutouts in their respective positions. Ensure that all equipment is tightly secured before descending pole.	(1) Protective equipment installation procedures shall be executed 100% correct.

2.1.8.1.

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NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
CEA JS 2.1.8.1
CLASS: 1 PRACTICAL: 6

TITLE: STRINGING SECONDARY MAINS

INTRODUCTION: This job sheet will guide you in the proper procedures for installing the secondary mains with related hardware and materials.

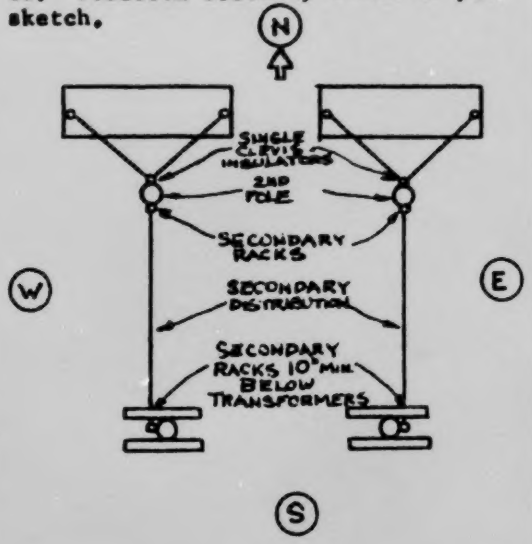
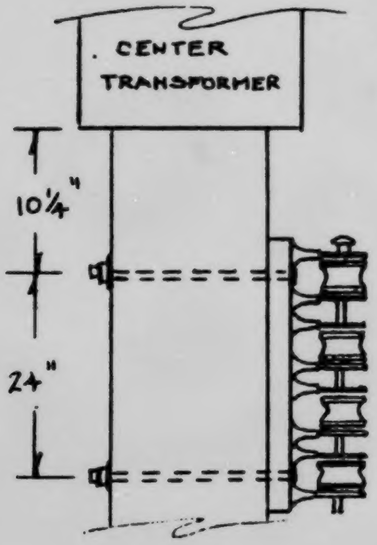
TOOLS AND EQUIPMENT: Lineman's tool kit, climbing gear, hard hat, secondary distribution hardware

MATERIALS: As listed in NAVFAC Dwg. No. 1109831

PROCEDURES: See attached procedures.

QUESTIONS: Instructor prepared

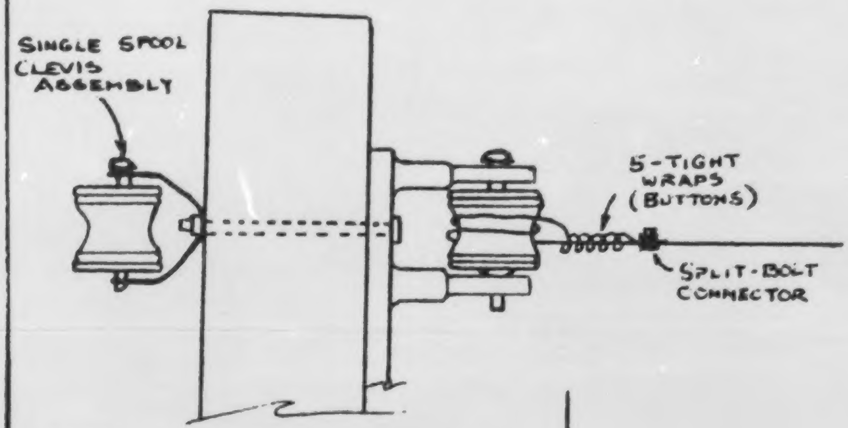
REFERENCES:
A. NAVPERS 10636-G, CE 3 & 2, Chapter 9
B. Lineman's and Cableman's Handbook, 4th Edition, Kurtz, Mc Graw-Hill Book Co., N. Y., N. Y.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Install secondary distribution system.	1a. Position Seconday racks as per sketch.  N SINGLE CLEVIS INSULATORS 2ND POLE SECONDARY RACKS W E SECONDARY DISTRIBUTION SECONDARY RACKS 10" MIN. BELOW TRANSFORMERS S	 CENTER TRANSFORMER 10¼" 24"
	1b. Groundman: Select: 2 - 4 Spool Secondary racks with spools 4 - Thru-bolts, length dependent upon pole diameter and 2" exposure. 6 - Curved washers	1b. For rack installation thru-bolt holes shall be 11/16" dia. for the 5/8" dia. bolts.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	6 - Spring washer 6 - Nuts 4 - Pre-cut lengths of #2 AWG insulated stranded copper conductors. 2 - Eye bolts 4 - 3/8" automatic dead-ending devices for #2 AWG triplex strained conductors. 2 - Pre-cut lengths of #2 AWG triplex (service drop).	
	1c. Lineman: Ascend transformer pole with handline and prepare to receive tools and materials.	
	1d. Lineman: With brace and 11/16" bit drill, First hole for rack, a min. of 10" below transformers. Drill second hole 24" down from center of top rack hole.	1d. Position of rack on transformer pole as per Sketch 1a.
	1e. Groundman: Select secondary rack and disassemble pin and insulator spools. Hoist to lineman, the disassembled rack with two thru-bolts with an equal number of curved washers, spring washers and nuts.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	1f. Lineman: Place secondary rack over the two thru-bolt holes and align top and bottom rack holes with holes in pole.	1f. When tightening nut apply pressure until spring washer is flat, then back off 1/4 of a turn to allow spring washer to expand and contract.
	(2) Install thru-bolts with bolt head against rack, and apply curved washer, spring washer and nut on opposite end.	
	1g. Groundman: Hoist to lineman the pin and four insulator spools. Ensure that pin is complete with a cotter key.	
	1h. Lineman: When installing insulators, position pin in top hole and align one insulator at a time as the pin is being installed. Insert cotter key and spread the ends approx. 1/2".	1h. Make sure that the spools are equally spaced throughout the length of the rack.
	1i. Groundman: Select the 4-lengths of #2 AWG stranded insulated copper conductors. Roll out each conductor between the two secondary poles. Using the handline, raise the conductors to the lineman, one at a time.	
	1j. Lineman: Secure first conductor to the top spool (secondary system neutral conductor) in accordance with the following sketch and the classroom display:	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	1k. Second pole: Install secondary rack and complete the installation of the secondary distribution system.	1k. Top hole for secondary rack thru-bolt will be located 10-1/4" from the top of the pole.
2. Installation of "Service Drop".	2a. Groundman: Select a single spool clevis complete with pin, insulator, spring washer and nut. Hoist to lineman. 2b. Lineman: Mount the single spool clevis assembly as per following sketch:	


SINGLE SPOOL CLEVIS ASSEMBLY
5-TIGHT WRAPS (BUTTONS)
SPLIT-BOLT CONNECTOR

Complete dead-ending of remaining conductors as per sketch.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	2c. Groundman: Select two premeasured lengths of #2 AWG stranded, insulated aluminum conductors (triplex), and two automatic dead-ending devices. Secure a device on each neutral conductor (approx. 30" back from end). Hoist one end of each service drop to the lineman, one at a time.	
	2d. Lineman: Place both wire bails of dead-ending devices on the single spool insulator, and replace pin and cotter key.	
	2e. Groundman: Place a dead-ending device on each service drop approx. 12" from end on neutral conductor.	
	2f. Lineman: Using a tag line, hoist end of triplex with automatic dead-end device and secure to a single-spool assembly mounted on angle iron. Sag cable accordingly by pulling slack thru the dead-end device. Repeat procedure at other service drop.	
	2g. Lineman: Complete service drop installation by splicing the neutral and phase conductors with split-bolt connectors. Tape each phase splice and leave the neutral untapped.	g. All secondary distribution installation procedures shall be executed 100% correct.

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 2.1.9.JS.1
CLASS: 1 PRACT: 4

TITLE: TRANSFORMER CONNECTIONS

INTRODUCTION: This job sheet will guide you in making the proper connections between the bank of three single-phase transformers, and the primary and secondary distribution systems.

TOOLS AND EQUIPMENT: Lineman's tool kit, climbing gear, hardhat.

MATERIALS: Jumper wires, split-bolt connectors

PROCEDURES: See attached.

QUESTIONS: Instructor prepared

REFERENCES:
A. CE 3 & 2, NAVPERS 10636-G, Chapter 9

B. Lineman's and Cableman's Handbook, 4th Edition, Kurtz, Mc Graw-Hill Book Co., New York, N. Y.

C. U. S. Department of Commerce, National Bureau of Standards, "Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines".

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Make primary distribution jumper connections at step-down transformer pole.	1a. Lineman: Ascend transformer pole and connect existing 6' ends of each phase conductor to the associated lightning arresters, fused cutouts and transformers in accordance with the attached drawing titled "Lightning Arresters, Fuse Cutouts, and Transformer Connections".	
	1b. Groundman: Select a 10-foot length of #6 AWG solid, hard-drawn, copper conductor and hoist to lineman.	
	1c. Lineman: Connect lightning arresters to existing grounding conductor on pole as per drawing titled. "Primary and Secondary Distribution Jumper Connections".	
	1d. Groundman: Select two four-foot pieces of #6 AWG solid hard-drawn bare copper conductors and hoist to lineman.	
	1e. Lineman: Connect 6' tail of overhead primary neutral conductor to the ground wire connecting lightning arresters. Connection shall be made with a split-bolt connector. Secure end of conductor to the nearest H_1 bushing.	1d. Ensure that bare high voltage conductors maintain the following clearances: 3" - Wooden crossarms and poles 6" - Metallic equipment and hardware
	1f. Complete neutral connection using the two four-foot pieces of #6 copper between the three H_1 bushings.	

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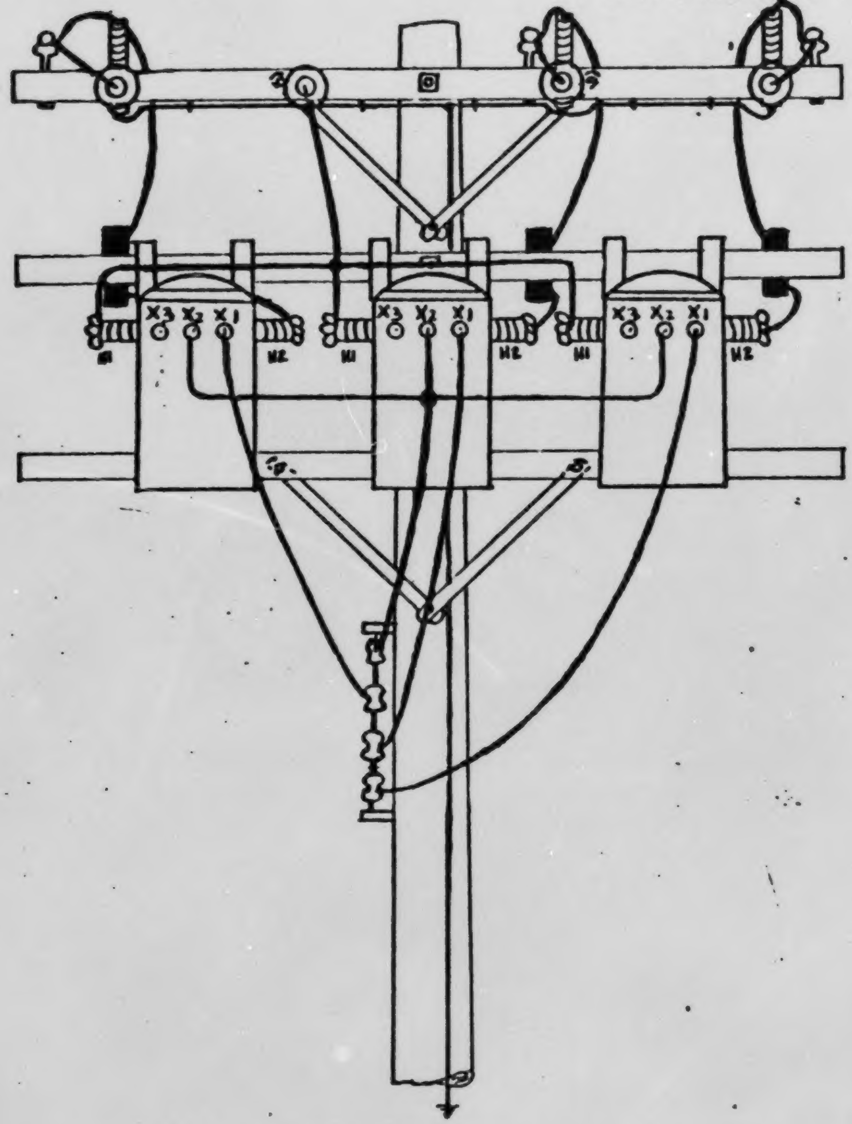
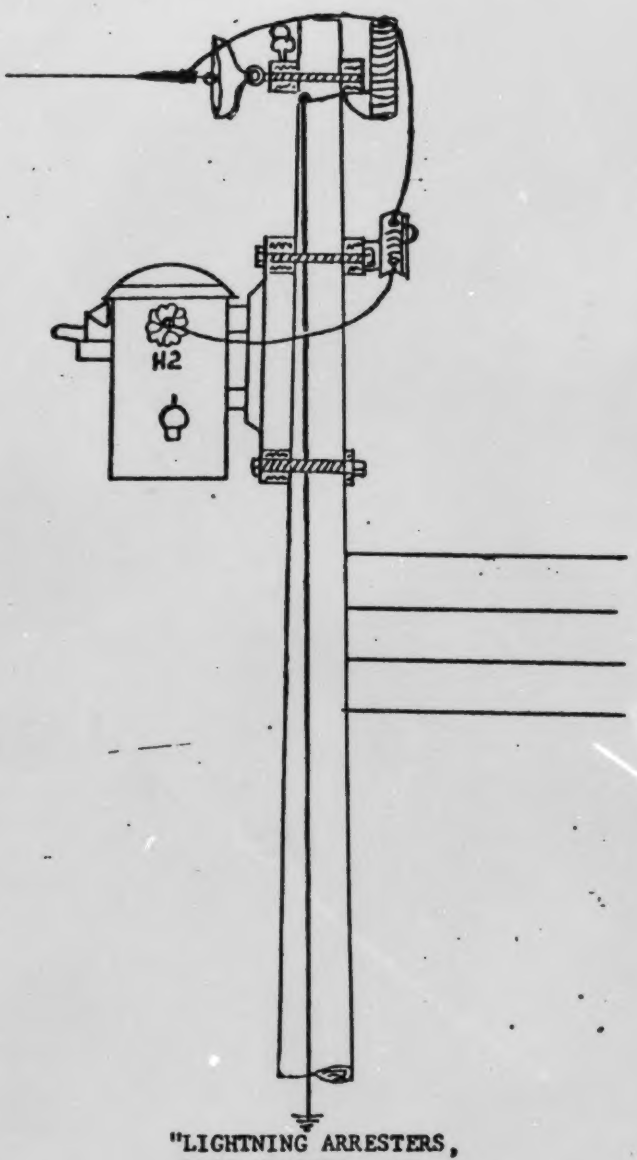
WHAT TO DO	HOW TO DO IT	KEY POINTS
2. Make secondary distribution jumper connections.	2a. Groundman: Select two four-foot pieces of #2 AWG stranded insulated, copper conductors and hoist to lineman.	
	2b. Lineman: Install the two four-foot pieces of jumper wires between the X_2 secondary bushings as per attached drawing.	
	2c. Completion of secondary hook-up shall be in accordance with the drawing titled "Primary and Secondary Distribution Jumper Connections".	2c. Measurements for jumpers shall be made to ensure proper length for connections and required clearances. All procedures shall be executed 100% correct.

CONSTRUCTION ELECTRICIAN'S SCHOOL
CEA 2.1.9.Dwg.1


X3
X2
X1
X3
X2
X1
X3
X2
X1
H1
H2
H1
H2
H1
H2

"PRIMARY AND SECONDARY DISTRIBUTION JUMPER CONNECTIONS"

(4 of 4)



"LIGHTNING ARRESTERS, FUSE CUTOUTS, AND TRANSFORMER CONNECTIONS"

NAVAL SCHOOLS CONSTRUCTION
PORT HUENEME, CALIF 93043
CE"A" 2.1.10.JS.1

TITLE: Pole Top Rescue

INTRODUCTION: This job sheet will guide you in the procedures for performance pole top rescue of an injured lineman under simulated conditions.

TOOLS AND EQUIPMENT.

A. Climbing gear

B. Hard hat

C. Handline

D. Harness with life-Line

E. Blanket

PROCEDURES: See attached

QUESTIONS: Instructor Prepared

REFERENCE:

A. CE 3 & 2 NAVPERS 10636-G, Chapter 9.

B. Lineman's and Cableman's Handbook 4th edition, Kurtz, Section 49, pp. 49-1 through 49-16.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Perform pole top rescue of an injured lineman.	1a. Rescuer #1 Make a quick survey of the victims accident situation and ensure that a rescue can be safely accomplished within a short period of time.	1a. Pole top situation Rescuer #1 will be working with intended victim on the pole at the time of the simulat accident.
	(1) If victim is in contact with a overhead conductor, use the proper non-conducting material to clear him from electrical contact.	(1) Speed is very important but the rescuer shall take all precauti for his own safety
	(2) Assume a position on the pole next to the victim so that you can swing his body over your safety strap	(2) Victim's body shall be position face up on the safety strap
	(3) The victims; head should be tilted into maximum extension by pressing upward on jaw with one hand and push the crown of the head back with the other hand.	(3) Cheek should seal the victims nostrils. If not, close nostrils by squeezing nose with hand.
	(4) Take a deep breath and seal your mouth across the victims mouth and breathe air into his lungs.	(4) If stomach bulges, press gently to remove excess air.
	(5) When victims chest expands remove your mouth and listen for escaping air	
	(6) Continue rescue breathing at the rate of 12 to 15 breaths per minute.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	2a. **Rescuer #2** After victim is positioned across rescuer #1's safety strap, proceed to climb to a position directly under the victim in order to apply "External Heart Resuscitation". (1) Position your arms around the upper chest of the victim, and locate the lower half of the breast bone just below it's center. (2) Place both hands on this position with thumb end of clenched fist against breat bone, and other hand applying pressure over clenched fist. (3) Exert pressure inward approx. 2" eight times.	2a. This procedure should be applied when there is absence of a heart beat or pulse.
	3a. **Rescuer #1** After each period of 5 pressure strokes, apply 2-rescue breaths.	
	4a. Continue these resuscitation cycles until the victim is revived.	
	5a. **Rescuer #1** When victim is revived and breathing on his own, prepare to lower him.	5a. If rescue harness is not available, the handline should be used by passing snap hook through both "D" rings and snap onto first "D" ring passed through.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(1) Signal to groundman to hoist the rescue tackle and harness.	(1) After harness is placed on the victim, the ground crew (3 men) will take a strain on the life-line to relieve the weight on rescuer #1's safety strap. Grou crew will strictly adhere to th commands from rescuers #1 & #2.
	(2) After receiving harness (with life-line attached) throw over crossarm and place harness on victim.	
	6a. Rescuer #2.Remove tool belt if using rescue harness after ensuring that all straps on the harness are secured properly	
	7a. Rescuer #1, Swing victim into a safe position for lowering to the ground	7a. Rescuer #2 will assist in position victim for lowering to the ground.
	(1) Signal to ground crew to begin lowering.	(1) Ensure that handline will not slip off the crossarm. Pin insulator shall be installed nea end of crossarm.
	(2) Ground crew will lower victim slowly and gently using the hand-over-hand method on the life-line.	
	(3) Life-line is guided by rescuers #1 & #2 to maintain victims descent to ground in a safe manner	
	(4) Place victim on a blanket and cover him after releasing harness.	(4) All steps of procedure shall be executed 100% correct.

2.1.11.1

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NAVAL SCHOOLS. CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 2.1.11.JS.1
CLASS: 3 PRACTICAL: 7

TITLE: POWER PLANTS

INTRODUCTION: This job sheet will guide you in the procedures for executing prestart checks, operating generators singly or in parallel, applying and equalizing load between generators.

EQUIPMENT: Generators - 3 - 15 KW, 4 - 100 KW, 1 - 150 KW, and 1 - 200 KW

PROCEDURES: See attached

QUESTIONS: Instructor prepared

REFERENCE:

A. NAVPERS 10636-G, CE 3 & 2, Chapter 3

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Prestart check of generators, prime movers and equipment (two - 15 KW units).	1a. Fuel Tanks - Verify that fuel tanks are full by reading level on fuel tank dip stick, or fuel gauge.	1a. Check for type of fuel (gas or diesel) required if level is low.
	1b. Crankcase Oil - Check by reading level on dip stick.	1b. Carefully follow manufacturer's procedures for properly checking oil level.
	1c. Radiator - Check water level and add if required.	
	1d. Batteries - Check liquid level and add distilled water if required.	1d. Use extreme care when adding distilled water to batteries. DO NOT OVERFILL.
	1e. Generator Circuit Breaker (Located on each generator). Place in the "Off" or the "Open" position.	1e. Ensure that the circuit breaker located in the switchboard is also in the "Open" position. Check small viewing window for breaker position.
	1f. Voltage Regulator Switch - Place switch in the Manual position and rotate field control knob to the maximum Decrease position.	1f. Prestart checks shall be executed 100% correct.
2. Starting primer mover.	2a Locate speed control and position half-way to its maximum and minimum position.	2a Ensure that the stop-control handle is pushed in all the way.
	2b. Locate engine-start-switch and depress to activate the battery-operated starting motor.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(1) Immediately after the engine fires, (operates on its own power), check the "lubricating oil pressure gage".	(1) If it does not indicate oil pressure within 10 seconds after the engine fires, stop the engine at once by pulling the stop - control handle out all the way.
	2c. Adjust speed control or frequency control vernier knob until the frequency registers 60 Hertz.	
	2d. Adjust voltage regulator rheostat knob until the A.C. voltmeter indicates 208 volts.	2d. On most generators, the output voltage is derived from a 3-phase, 4-wire wye configuration, or phase-to-phase (208 volts), and phase-to-ground (120 volts).
	2e. Recheck all meters for correct frequency, voltage, oil pressure, water temperature and battery charging ammeter.	
	2f. When all systems appear normal, place voltage regulator in the automatic position and adjust voltage to 208 volts.	2f. Starting procedures shall be performed 100% correct. IG - Note: Prime movers should be up to operating temperature before applying load. Cold application of load can cause damage to both generator and prime mover.
3. Apply resistor load to generator (for single operation).	3a. Check main breaker on the load bank. (Place in the Off position).	3a. If this breaker is in the On position when the switchboard circuit breaker is place in the On position, the Gen. C.B. will trip.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	3b. Place the generator circuit breaker to the On position or Closed position.	
	3c. Place the switchboard circuit breaker to the On or Closed position	
	Note: The load bank cooling fan warning signal will operate for approximately 2 seconds.	3d. Place the switchboard buss-tie breaker in the On or Closed position by pressing the Closed button. (Black button)
	3e. Place the load-bank main circuit breaker in the "On" position and check voltage on load bank voltmeter and frequency meter.	
	3f. Apply small load of 7 KW to warm the generator and activate the governor and voltage regulator. Check and readjust both volts and Hertz, if required.	3f. The 7 KW resistor load will indicate approximately 33.6 amps (run at this load for approx. 5 min.)
	3g. Apply additional load of 10 KW for a total of 17 KW - a 2 KW overload. Check readings.	3g. Check for proper voltage regulator and governor operation. (Run at overload for approx. 2 - 5 min.)
	3h. Reduce load by disconnecting 7KW, and prepare second generator for parallel operation.	3h. Second 15 KW unit should be up to operating temperature and ready for parallel operation.
	3i. Check volts and amps across all phases by turning the appropriate selector switches.	3i. Volts and amps readings should be the same across all phases.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	3j. Check water cooling and lube oil pressure on both units.	
4. Parallel operation (for 2 - 15 KW units)	4a. Place generator main breaker to On Position on No. 2 unit.	4a. This will connect 2nd unit to main buss for parallel operation.
	4b. Place the synchronizing lamp switch (on the power unit to be paralleled) in the On position.	
	4c. Turn the vernier knob on #2 unit, until both units are operating at approximately the same frequency. The sync. lamps will glow and go out at a very slow rate.	4c. When equal speed is obtained, the matching frequencies will be indicated by the slow change in the brillance of the synchronizing lamps.
	4d. Stand by the switchboard breaker (for the generator to be paralleled) and wait until lamps go out. At that moment, place breaker in the On position.	
	4e. Adjust vernier knob (on No. 2 unit) to increase speed to share 1/2 of the 10 KW load. Check Hertz, volts and amps on the two units, and ensure that the load is equally distributed.	
5. Securing parallel operation.	5a. On #2 unit disconnect switchboard circuit breaker, disconnect generator circuit breaker, place voltage regulator switch to the manual position, decrease voltage to 0, slow engine (with vernier) to idle speed, pull engine stop knob all the way out, after engine stops, push knob all the way in.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	5b. Disconnect 10 KW load and main circuit breaker on the load bank.	
	5c. Open the buss-tie breaker (red button)	
	5d. Place the switchboard circuit breaker in the Off position.	
	5e. Place the generator main breaker in the Off position.	
	5f. Place voltage regulator switch to the manual position and decrease voltage to 0.	
	5g. Slow engine (with vernier) to idle speed, pull engine stop knob all the way out. After engine stops, return knob to normal start position.	5g. Single and parallel resistor load operation and securing procedures shall be executed 100% correct. IO Note: Before securing either unit (after students have completed their practical performance) allow for cooling time to lower temperatures, approx. 15-20 minutes.

2.1.12.1

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NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 2.1.12.JS.1
CLASS: 1 PRACTICAL: 2

TITLE: SYSTEMS TESTING

INTRODUCTION: This job sheet will guide you in the proper procedures in testing and recording ground resistance, voltage and amperage using a vibroground tester, multimeter (Simpson 260) and a Snap-on ammeter-voltmeter.

TOOLS AND EQUIPMENT: Lineman's climbing gear and tool kit, vibroground test meter, Simpson 260 (Multimeter), Snap-On ammeter-voltmeter.

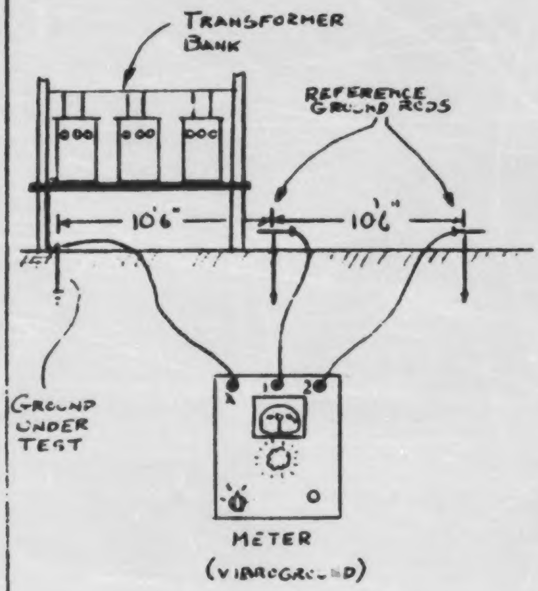
MATERIALS: None

PROCEDURES: See attached.

QUESTIONS: Instructor Prepared

REFERENCE:

A. CE 3 & 2, NAVPERS 10636-G, Chapter 4

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Check primary, secondary and service grounds (before energizing system) using vibroground test equipment.	1a. Locate primary step-up transformer bank-driven ground rod. 1b. Set up the two reference grounds as per sketch:  TRANSFORMER BANK REFERENCE GROUND RODS 10'6" 10'6" GROUND UNDER TEST X 1 2 METER (VIBROGROUND) (1) Use LEATHER hammer to drive reference grounds. Leave approx. 1-1/2" of top of each rod exposed above ground.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	1c. Attach jumper wires and make connections as per sketch 1b.	
	1d. Set "Range Selector" on vibroground test set to the multiply by 10 scale.	1d. Vibroground test set: (1) Ground connections - Terminal X is always connected to the ground rod to be tested. Terminals 1 and 2 are reference grounds. (2) Balance meter - Shows balance point for taking readings. Arrows indicate direction to turn potentiometer. (3) Balancing potentiometer - Gives true ground resistance reading to 0.1 OHMS times range multiplier. When knob is turned to obtain a balanced needle. (4) Range selector - Multiply by 1-10-100-1000. Example: Balancing potentiometer reads 1.8. Range selector is on 10 Solution 1.8 X 10 = 18 OHMS (5) Operating lever switch - Pressed upward, it energizes instrument at reduced sensitivity, pressed downward, gives maximum sensitivity for final adjustment of balancing poteniometer. Spring return protects

WHAT TO DO	HOW TO DO IT	KEY POINTS
		instrument against accidentally left on between measurements.
	1e. Operate "lever switch" to up or Adj. position.	
	1f. Set "balancing potentiometer" to a point where needle is in the center position.	1f. Arrows on dial will show the direction to move the knob when required.
	1g. Place "operating lever switch" into Read position and readjust potentiometer if required.	
	1h. Multiply reading by 10 and notify instructor if resistance is more than 3 OHMS.	1h. Grounding requirement for substations and switching stations on primary systems shall not exceed 3 OHMS.
	1i. Perform ground checks on secondary transformer pole and dwelling service. Follow steps of procedure outlined in Items 1a through 1h.	1i. Adhere to safety requirements when working with vibroground test equipment: (1) Do not drop test set. (2) Do not operate "Operating Lever Switch" for extended periods of time. (3) Do not drive reference ground rods to any more or less than 1-1/2" out of the ground. (4) Do not exceed 10' 6" between rods.

WHAT TO DO	HOW TO DO IT	KEY POINTS
2. Energize power plant.	2a. Follow procedures outlined in Topic 2.1.11, Job Sheet CEA 2.1.11. JS.1, "Power Plants".	
3. Check voltage at dwelling distribution panels: Phase-to-Phase and Phase-to-Ground.	3a. Select a multimeter and set the following range: 0-250 volts.	3a. On secondary distribution you will be reading voltages less than 250 volts.
	3b. Secure multimeter in a position above the distribution panel.	3b. Eye height for easy viewing and to ensure against dropping.
	3c. If the approximate voltage of the circuit to be tested is unknown, start with the highest voltage range.	3c. The 1000V scale. If reading is approx. 240V. Move selector to 250V scale.
	3d. Make the following voltage checks and record the readings: (1) With test leads across the two incoming hot leads, Read and record voltage. (2) With test leads across each hot lead and ground, Read each voltage and record.	
	3e. Return multimeter to tool room.	
4. Check amperage at the secondays distribution mains, service drops and individual dwelling circuits.	4a. Select a clamp-on type ammeter-voltmeter.	4a. Amprobe scales as follows: Ammeter - 0 to 6-15-40-100-300 Voltmeter - 0 to 150-300-600
	4b. Don climbing gear and ascend the secondary distribution transformer pole.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	4c. Assume a working position between the 4-spool secondary rack and the single-spool clevis assembly.	
	4d. Check each phase conductor and neutral on the secondary distribution system.	4d. Set meter on the 0-100 ammeter scale before using. If reading is less than 40 move to 0-40 scale. If less than 15, move to 0-15.
	4e. Inform a recorder on the ground of ammeter reading on each hot phase and neutral.	
	4f. Check each service drop for amperage reading at the drip loops.	
	(1) Inform recorder of ammeter readings on West and East service drops.	
	4g. Descend transformer pole and prepare to take readings at the interior distribution panels.	
	4h. Place the main disconnect in the "Off" position.	4i. Start with either West or East panel.
	4i. Position each branch circuit conductor with a loop for accessible operation of the clamp-on ammeter.	
	4j. Place the main disconnect in the On position.	
	4k. Check each branch circuit and record ammeter readings.	4l. Repeat same procedures with remaining panel.

WHAT TO DO	HOW TO DO IT	KEY POINTS
	4l. Add ammeter loads of individual branch circuits and compare with the load readings on the main secondary distribution conductors.	
	4m. All circuit checking procedures shall be executed 100% correct.	

2.1.13.1

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NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA 93043
CEA 2.1.13.JS.1
CLASS: 1 PRACT: 11

TITLE: DISASSEMBLE POLE LINE

INTRODUCTION: This job sheet will guide you in the proper procedures required to disassemble a pole line, and store all the equipment and hardware.

TOOLS AND EQUIPMENT: Lineman's tool kit, climbing gear, hard hat, handline, tag line, wire grips, pole-top gin, block and tackle

MATERIALS: None

PROCEDURES: See attached procedures

QUESTIONS: Instructor Prepared

REFERENCES: None

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Remove primary conductors from fused cutouts at platform-mounted transformer bank.	1a. Lineman: Ascend platform assembly and assume a position to disconnect primary conductors from bottom terminals of fused cutouts.	1a. This initial disassembly procedure will ensure against the possibility of accidentally energizing the line.
2. Disconnect and remove primary and secondary jumper wires at the secondary distribution transformer pole.	2a. Lineman: Ascend transformer pole with handline secured to belt. (1) Secure handline above top crossarm.	
	2b. Groundman: Hoist the linemans kit of tools required to disconnect jumper wires.	
	2c. Lineman: Disconnect and remove primary and secondary jumper wires, and jumper wires inter-connecting the transformers.	2c. All jumper ties, jumper wires and hardware shall be lowered to the ground using the "grunt" bag. "Do not drop anything to the ground".
3. Remove service drops, secondary mains and associated hardware.	3a. Lineman: Disconnect service drops from secondary distribution mains.	
	(1) Remove neutral (of tri-plex cable assembly) from the single-spool clevis assembly. Lower end of cable to ground with handline.	(1) Ground crew - Complete remova of tri-plex cables, coil and stow as directed.
	(2) Remove single-spool clevis assembly and lower to groundman.	
	3b. Lineman: Remove and lower each secondary conductor.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(1) Remove secondary rack and lower with handline.	
4. Remove primary conductors between transformer pole and corner pole.	4a. Groundman: Select a "wire grip" and raise to lineman.	
	4b. Lineman: Apply wire grip on outside conductor. Secure clip end of handline to wire grip. Notify ground crew to take a strain on conductor before cutting conductor an inch from where it enters dead-ending device.	4b. The two outside conductors will be removed first before removing the inside conductors.
	(1) Lower conductor to the ground.	(1) Use handline on wire grip when lowering conductor.
	4c. Lineman: Ascend corner pole and remove other ends of primary conductors and lower to the ground.	
	(1) Groundman: Coil conductors in a continuous coil using pressure splicing devices.	
5. Remove lighning arresters, pin insulators, fused cutouts and dead-end clevis assemblies at the transformer pole.	5a. Lineman: Remove lightning arresters from their L-brackets and lower to the ground. Remove L-brackets.	
	(1) Remove pin insulators, fused cutouts and dead-end assemblies.	(1) Lower all procelain items very carefully.
	(2) Stow gear as directed.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
6. Remove transformers (secondary distribution)	6a. **Groundman**: Raise pole-top gin to lineman.	
	6b. **Lineman #2**: Ascend pole and assist Lineman #1 in securing pole-top gin to top of pole.	
	6c. **Groundman**: Raise block and tackle, wire sling and tag line to lineman.	
	6d. **Linemen #1 & #2**: Secure block and tackle to pole-top gin with fall line coming from top block.	
	(1) Secure wire sling to center transformer and attach block and tackle to wire sling.	
	(2) Attach tag line to transformer using a timber hitch.	
	6e. **Ground crew**: Take a strain on block and tackle fall line until transformer hanger clears the supporting crossarm.	
	(1) Lower transformer to ground.	(1) Crew member will steady transformer descent with tag line. Move transformer away from base of pole before lowering #2 and #3.
	(2) Repeat steps of procedures on the two remaining transformers.	
	(3) Store transformers as directed by instructor.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
7. Remove remaining primary conductors.	7a. **Lineman**: Ascend corner pole (next pole in line after transformer pole) with handline. (1) Secure handline above the top crossarm. 7b. **Groundman**: Hoist lineman's tools and wire grips. 7c. **Lineman**: Remove tie wires from all line pin insulators. (1) Attach wire grip on outside conductor. (2) Attach clip of handline to wire grip.	
	(3) Take a strain on wire grip before cutting conductor at the automatic dead-end device.	(3) If conductor is cut while there is slack on the line, the next pole in line will vibrate back and forth causing possible hazard to a lineman on that pole.
	7d. **Groundman**: Lower conductor to the ground.	7d. Use handline on wire grip when lowering conductor.
	7e. **Lineman**: Remove remaining conductors as per 7a - 7d. (1) Remove all associated hardware.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(2) Repeat procedures for removing primary conductors on remaining poles.	
	7f. Groundmen: Splice conductors together and roll into 2 coils.	
8. Remove guys and guying hardware.	8a. Lineman: Ascend guyed pole with handline.	
	(1) Secure handline above top crossarm.	
	8b. Groundman: Hoist lineman's tools and wire grip.	
	8c. Lineman: Attach wire grip to guy wire.	
	(1) Attach clip of handline on wire grip.	
	8d. Groundman: Take a strain on the handline.	
	8e. Lineman: Remove thru-bolt holding guy attachment to the pole.	
	8f. Groundman: Lower guy assembly to the ground.	
	(1) Remove preformed guy grips from guy assembly.	
	(2) Remove strand vise from anchor rod.	

WHAT TO DO	HOW TO DO IT	KEY POINTS
	(3) Roll guy strands into a coil and identify with a tag stating assigned pole.	
	(4) Store hardware and guy strands as directed by instructor.	
9. Remove hardware and crossarms.	9a. Linemen #1 and #2: Ascend pole with handline.	
	(1) Secure handline above top crossarm.	
	9b. Groundman: Hoist lineman's tool kit.	
	9c. Linemen #1 and #2: Remove dead-end clevis assemblies, pin insulators and carefully lower items to the ground.	
	(1) Secure handline to crossarm with clove and half hitch.	
	(2) Remove flat brace lag screws, nuts and washers.	(2) On double arm, allow thru-bolt to support one crossarm while opposite crossarm is lowered to the ground.
	(3) Lower crossarms.	
	9d. Groundmen: Store all line material as directed by the instructor.	
	9e. Lineman: Remove handline before descending pole.	e. All steps of procedure shall be executed 100% correct.
	(1) Make up handline and store in a hanging position.	

MODIFICATIONS

Job Sheet 2.2.1.1 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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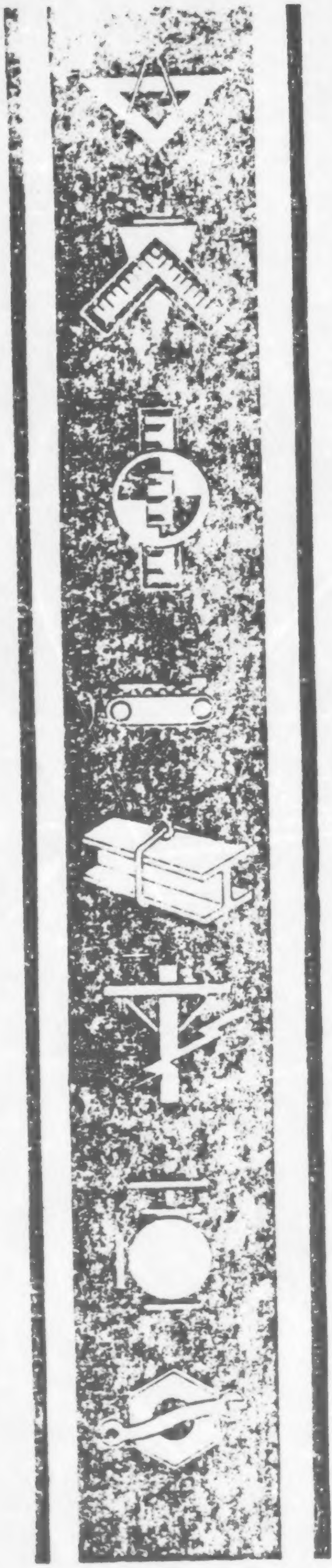

NAVAL SCHOOLS, CONSTRUCTION
PORT HUENEME, CALIFORNIA
93043

SERIES: 058/551A

ELECTRICAL SYMBOLS

3-16

DEPARTMENT OF THE NAVY

479

SERIES: 058/551A
PROGRAM DATE: 1 Dec 1970

ELECTRICAL SYMBOLS

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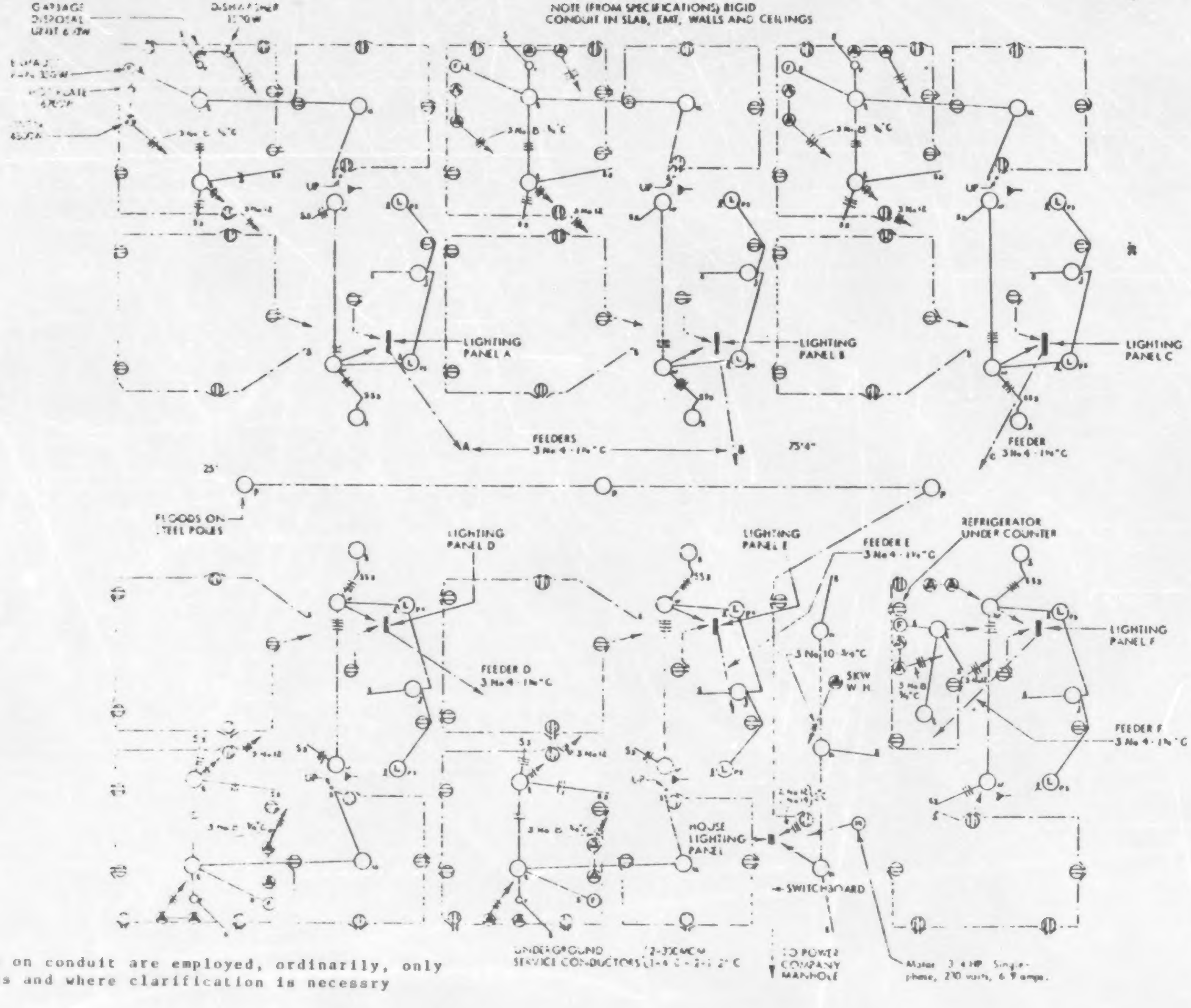

NOTE (FROM SPECIFICATIONS) RIGID CONDUIT IN SLAB, EMT, WALLS AND CEILINGS
GARBAGE DISPOSAL UNIT 6 ?W
DISHWASHER 1200W
EXHAUST FAN 100W
HOT PLATE 4800W
OVEN 4500W
3 No 8 ¾"C
3 No 12
UP
LIGHTING PANEL A
LIGHTING PANEL B
LIGHTING PANEL C
FEEDERS 3 No 4 - 1¼"C
FEEDER 3 No 4 - 1¼"C
75'4"
25'
FLOODS ON STEEL POLES
LIGHTING PANEL D
LIGHTING PANEL E
FEEDER E 3 No 4 - 1¼"C
REFRIGERATOR UNDER COUNTER
LIGHTING PANEL F
FEEDER D 3 No 4 - 1¼"C
3 No 10 - ¾"C
5KW W.H.
3 No 8 ¾"C
FEEDER F 3 No 4 - 1¼"C
HOUSE LIGHTING PANEL
SWITCHBOARD
UNDERGROUND SERVICE CONDUCTORS
2-350MCM 1-4 G - 2-1 2"C
TO POWER COMPANY MANHOLE
Motor 3/4 HP Single-phase, 230 volts, 6.9 amps.

Cross marks on conduit are employed, ordinarily, only on home runs and where clarification is necessary

TO THE STUDENT:

The ability to read and understand an archetectural and electrical layout drawing, like the one on the opposite page, is part of the job of the Engineering Aid and the Construction Electrican. If the EA were required to draw a picture of all the components on the drawing, it would take forever to make and be too large to be practical for the field.

Subsequently, the Department of Defense, with the approval of the American Standards Association, has standardized a system of symbols to represent these components. This booklet uses a lively, stimulating, and unique way of teaching some of the most commonly used symbols through an assortment of quizzes and tests.

When there is more than one symbol for a specific component both will be used. Consequently, a legend is required on the drawing to identify each individual symbol and reference to this legend is recommended at all times.

Though this booklet uses quizzes and tests throughout, the programmed Instruction should not be regarded as a test, but a learning guide.

The most effective way to use this program is to study it at your own pace. The guide is broken into small steps, usually one per page, with a teaching body, a question, and a choice of answers on each page. The correct answers to the questions are located at the top of the next page.

Read each step carefully and be able to answer each question before proceeding to the next page. DO NOT LOOK AHEAD. You may look back if you tend to forget any of the information. You may ask your instructor for help at any time if you feel you need it.

TURN TO NEXT PAGE
AND READ YOUR OBJECTIVES ...

UPON THE COMPLETION OF THIS PROGRAM, YOU WILL BE ABLE TO:

Identify, using the correct nomenclature, various electrical symbols used on electrical floor plans.

IN ORDER TO DO THE ABOVE OBJECTIVE, YOU WILL BE REQUIRED TO:

1. Identify, when given a list of electrical symbols, the proper wiring designations, the branch circuits, and the miscellaneous control items that the symbols represent;
2. Identify, when given a list of electrical symbols indicating lighting fixture outlets, if the symbol is an incandescent or fluorescent light, a junction box, a night light, or an exit light, and whether it is ceiling or wall mounted;
3. Identify, when given a list of electrical symbols indicating convenience outlets, if the symbol is a duplex or other than duplex, a weatherproof, a range, a switch, a special purpose, or a floor mounted; and
4. Identify, when given a list of electrical symbols indicating switch outlets, if the symbol is a single or two pole, a three or four way, a thermostat, an isolating, or a push button or pull switch, ceiling or wall mounted.

TURN TO THE NEXT PAGE
AND START YOUR PROGRAM ...

In order to make learning what the symbols on an electrical print represent easier, let's trace an electrical circuit from the source to the fixtures and then return to the panel.

The National Electrical Code says that the circuit conductor between the service equipment, or the generator switchboard of an isolated plant, and the branch circuit overcurrent device is called the feeder.

The symbol for a feeder is an extra heavy line:

(━━━━━━)

LISTED BELOW ARE FOUR ELECTRICAL SYMBOLS, THREE (3) REPRESENT BRANCH CIRCUITS AND ONE (1) REPRESENTS A FEEDER. PLACE A CHECK (✓) MARK NEXT TO THE ELECTRICAL SYMBOL THAT REPRESENTS THE CONDUCTOR BETWEEN THE SERVICE EQUIPMENT AND THE OVERCURRENT DEVICE:

____ A. ────────────

____ B. ───── – ─────

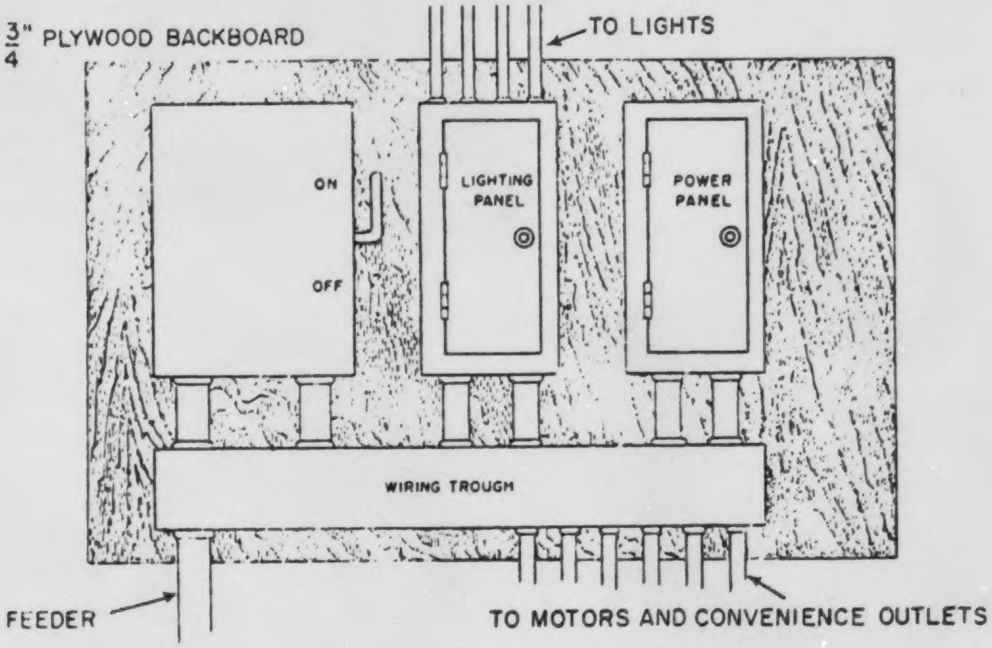
____ C. - - - - - - - - - - -

____ D. ━━━━━━━━━━━━

TURN TO NEXT PAGE ...

ANSWER: ✓ D. ________

The illustration below shows a typical layout for the entrance switch, lighting, and power panels.


$\frac{3}{4}$" PLYWOOD BACKBOARD
TO LIGHTS
ON
OFF
LIGHTING PANEL
POWER PANEL
WIRING TROUGH
FEEDER
TO MOTORS AND CONVENIENCE OUTLETS

The symbols for the lighting and power panels are:

Lighting Panel	(■)
Power Panel	(▨)

IN THE SPACE PROVIDED, DRAW THE ELECTRICAL SYMBOL NEXT TO THE NAME THAT IT REPRESENTS:

A. FEEDER	( )
B. LIGHTING PANEL	( )
C. POWER PANEL	( )

TURN TO NEXT PAGE ...

ANSWERS: A. LIGHTING PANEL

B. POWER PANEL

C. MOTOR CONTROLLER

D. MOTOR

Now that we have covered the feeder, panels, and controller, let's get the electricity to the fixtures. The portion of a wiring system extending beyond the final overcurrent device protecting the circuit is called a branch circuit.

There are three (3) ways of symbolizing a branch circuit:

Concealed in Ceiling or Wall (———)

Concealed in Floor (— — —) or (— — —)

Exposed (--------)

IN THE SPACES PROVIDED, IDENTIFY THE SYMBOLS WITH THE NAME OF THE ELECTRICAL COMPONENT:

(▬▬▬) A. ______________

(———) B. ______________

(— - —) or (— — —) C. ______________

(-------) D. ______________

TURN TO NEXT PAGE ...

ANSWERS: A. (━━)

B. (▬)

C. (▨)

The National Electrical Code states that a controller is required for all motors. It is a device, or group of devices, which serves to govern, in some predetermined manner (stop, start, and reset), the electrical power delivered to the motor to which it is connected.

The symbols for the motor and the controller are:

(Ⓜ) INDICATES A MOTOR

(⊠) INDICATES A MOTOR CONTROLLER

IN THE SPACES PROVIDED, IDENTIFY THE ELECTRICAL SYMBOLS BELOW:

(▬) A. ____________________

(▨) B. ____________________

(⊠) C. ____________________

(Ⓜ) D. ____________________

TURN TO NEXT PAGE ...

ANSWERS: A. FEEDER

B. BRANCH CIRCUIT (CONCEALED IN CEILING OR WALL)

C. BRANCH CIRCUIT (CONCEALED IN FLOOR)

D. BRANCH CIRCUIT (EXPOSED)

ANY Branch Circuit without further designation indicates a two (2) wire circuit:

EXAMPLE: (————) Two (2) wires

NOTE: THE SYMBOL IS THE SAME AS THAT OF THE BRANCH CIRCUIT (CONCEALED IN CEILING OR WALL).

For a greater number of wires indicate as follows:

(——///——) Three (3) wires

(——////——) Four (4) wires

CHECK (✓) THE CORRECT WAY OF INDICATING A FIVE WIRE BRANCH CIRCUIT:

____ A. ($\overset{5}{\rule{4em}{0.4pt}}$)

____ B. (——/////——)

____ C. (————)

____ D. ($\overset{/////}{\rule{4em}{0.4pt}}$)

TURN TO NEXT PAGE ...

ANSWER:

✓ B. (—////—)

Let's cover one more item that comes under the same category as a branch circuit. The HOME RUN symbol resembles that of a branch circuit concealed in a ceiling or wall, except that the number of circuits is indicated by a number of arrows.

EXAMPLE:

(——►►) INDICATES TWO (2) CIRCUITS RETURNING TO THE PANEL.

(——►►►) INDICATES THREE (3) CIRCUITS RETURNING TO THE PANEL.

IN THE SPACES PROVIDED, INDICATE BY DRAWING THE REQUESTED SYMBOL:

A. TWO CIRCUIT HOME RUN ( )

B. THREE WIRE BRANCH CIRCUIT ( )

C. TWO WIRE BRANCH CIRCUIT ( )

D. FOUR WIRE BRANCH CIRCUIT ( )

TURN TO NEXT PAGE ...

ANSWERS:

A. (———►►)

B. (—///———)

C. (————)

D. (—////——)

Up to this point you have learned twelve (12) symbols, let's see if you remember them, and take a quick stop and review ...

COMPLETE THE FOLLOWING:

THIS SYMBOL (━━━━) REPRESENTS A/AN

____

CHECK YOUR ANSWER ...

ANSWER: FEEDER

HOW ABOUT THESE FOUR SYMBOLS, DO YOU REMEMBER WHAT THEY REPRESENT?

(▬) A. ____________________

(▨) B. ____________________

(☒) C. ____________________

(Ⓜ) D. ____________________

CHECK YOUR ANSWERS ...

ANSWERS:

A. LIGHTING PANEL

B. POWER PANEL

C. MOTOR CONTROLLER

D. MOTOR

I BET YOU REMEMBER THESE SYMBOLS WITHOUT ANY TROUBLE:

(———) A. ____________________

(— — —) or (— - —) B. ____________________

(- - - - - -) C. ____________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

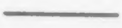
ANSWERS:

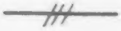
A. BRANCH CIRCUIT (CONCEALED IN CEILING OR WALL)

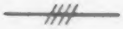
B. BRANCH CIRCUIT (CONCEALED IN FLOOR)

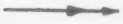
C. BRANCH CIRCUIT (EXPOSED)

AND THE LAST OF THE SYMBOLS YOU HAVE JUST LEARNED:

() A. ____________________

() B. ____________________

() C. ____________________

() D. ____________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

ANSWERS: A. TWO WIRE BRANCH CIRCUIT

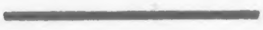
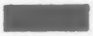
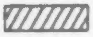
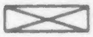
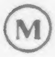
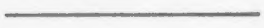
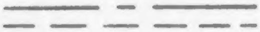
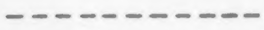
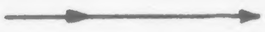
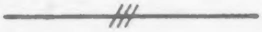
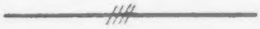
B. THREE WIRE BRANCH CIRCUIT

C. FOUR WIRE BRANCH CIRCUIT

D. HOME RUN TO PANEL (2 CIRCUITS)

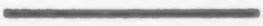
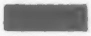
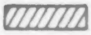
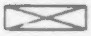
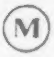
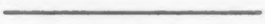
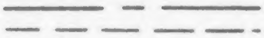
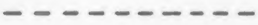
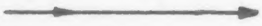
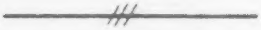
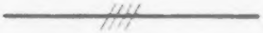
GO ON TO THE NEXT PAGE TO SEE IF YOU GOT THE FIRST OBJECTIVE DOWN PAT ...

IN THE SPACES PROVIDED, IDENTIFY THE ELECTRICAL SYMBOLS:

SYMBOL	NAME
	1. ____________________
	2. ____________________
	3. ____________________
	4. ____________________
	5. ____________________
	6. ____________________
	7. ____________________
	8. ____________________
	9. ____________________
	10. ____________________
	11. ____________________

TURN TO NEXT PAGE ...

ANSWERS:

SYMBOL	NAME
	1. Feeder
	2. Lighting Panel
	3. Power Panel
	4. Motor Controller
	5. Motor
	6. Branch Circuit (Concealed in Ceiling or Wall) 2 Wire Circuit
	7. Branch Circuit (Concealed in Floor) 2 Wire Circuit
	8. Branch Circuit (Exposed) 2 Wire Circuit
	9. 2 Home Runs to Panelboard
	10. 3 Wire Branch Circuit
	11. 4 Wire Branch Circuit

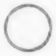
TURN TO NEXT PAGE ...

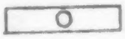
13.

If you were to look at an electrical print, you'd be able to follow a circuit from a source to a fixture and return to the panel. Since you are out at the fixtures, let's see what those circles and squares represent.

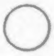
There are two types of lighting fixtures - incandescent and fluorescent - and they can be mounted on the ceiling or wall.

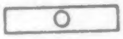
Their symbols are:

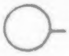
() Indicates an incandescent fixture outlet, ceiling mounted; and

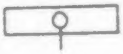
() Indicates a fluorescent fixture outlet, ceiling mounted.

WHICH SYMBOLS BELOW REPRESENT AN INCANDESCENT AND A FLUORESCENT FIXTURE OUTLET, CEILING MOUNTED, CHECK (✓) THE CORRECT ANSWERS:

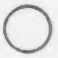
___ A. ()

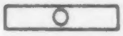
___ B. ()

___ C. ()

___ D. ()

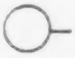
TURN TO NEXT PAGE ...

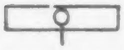
ANSWERS: ✓ A. ()

✓ B. ()

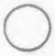
On the previous page, it said that the two lighting fixture outlets could be ceiling or wall mounted.

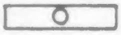
The symbols that represent the wall mounted lighting fixtures are:

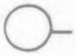
() Indicates an incandescent fixture outlet, wall mounted; and

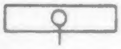
() Indicates a fluorescent fixture outlet, wall mounted.

WHICH SYMBOLS BELOW REPRESENT AN INCANDESCENT AND A FLUORESCENT FIXTURE OUTLET, WALL MOUNTED, CHECK (✓) THE CORRECT ANSWERS:

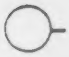
___ A. ()

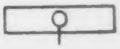
___ B. ()

___ C. ()

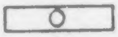
___ D. ()

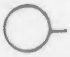
TURN TO NEXT PAGE ...

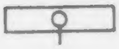
ANSWERS: ✓ C. ()

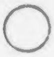
✓ D. ()

BEFORE YOU GO ON TO A NEW SYMBOL, LET'S SEE IF YOU CAN IDENTIFY THESE SYMBOLS. PLACE YOUR ANSWERS IN THE SPACES PROVIDED:

() A. ______________________________

() B. ______________________________

() C. ______________________________

() D. ______________________________

CHECK YOUR ANSWERS ON
THE NEXT PAGE ...

ANSWERS: A. FLUORESCENT FIXTURE OUTLET, CEILING MOUNTED

B. INCANDESCENT FIXTURE OUTLET, WALL MOUNTED

C. FLUORESCENT FIXTURE OUTLET, WALL MOUNTED

D. INCANDESCENT FIXTURE OUTLET, CEILING MOUNTED

The American Standards Association puts electrical symbols into six categories. In the General Outlets category the ASA uses the incandescent fixture outlet, ceiling mounted as a basic symbol, and by placing a letter - (J) for junction box or (X) for exit light outlet - within the symbol, it differentiates between each symbol.

IN THE SPACES PROVIDED, DRAW THE ELECTRICAL SYMBOL NEXT TO THE NAME THAT IT REPRESENTS:

A. A JUNCTION BOX, CEILING MOUNTED ( )

B. AN EXIT LIGHT OUTLET, CEILING MOUNTED ( )

C. AN INCANDESCENT FIXTURE OUTLET, CEILING MOUNTED ( )

D. AN INCANDESCENT FIXTURE OUTLET, WALL MOUNTED ( )

TURN TO NEXT PAGE ...

ANSWERS: A. (Ⓙ) A JUNCTION BOX, CEILING MOUNTED

B. (ⓧ) AN EXIT LIGHT OUTLET, CEILING MOUNTED

C. (○) AN INCANDESCENT FIXTURE OUTLET, CEILING MOUNTED

D. (○—) AN INCANDESCENT FIXTURE OUTLET, WALL MOUNTED

The same rule applies to wall mounted outlets as that of the ceiling mounted outlets. The basic symbol is that of the incandescent fixture outlet, wall mounted.

IN THE SPACES PROVIDED, DRAW ELECTRICAL SYMBOLS TO REPRESENT THE NAMES GIVEN:

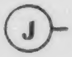
A. A JUNCTION BOX, WALL MOUNTED ( )

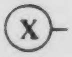
B. AN EXIT LIGHT OUTLET, WALL MOUNTED ( )

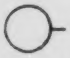
C. AN INCANDESCENT FIXTURE OUTLET, WALL MOUNTED ( )

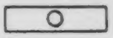
D. A FLUORESCENT FIXTURE OUTLET, CEILING MOUNTED ( )

TURN TO NEXT PAGE ...

ANSWERS: A. () A JUNCTION BOX, WALL MOUNTED

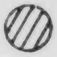
B. () AN EXIT LIGHT OUTLET, WALL MOUNTED

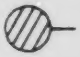
C. () AN INCANDESCENT FIXTURE OUTLET, WALL MOUNTED

D. () A FLUORESCENT FIXTURE OUTLET, CEILING MOUNTED

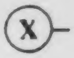
The last symbol covered in this General Outlets category is that of the night light outlet.

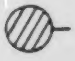
The symbol is that of the basic symbol plus cross-hatching and you have:

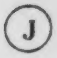
() A night light outlet, ceiling mounted; &

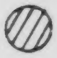
() A night light outlet, wall mounted.

IDENTIFY, IN THE SPACES PROVIDED, THE SYMBOLS LISTED BELOW:

() A. ______________________

() B. ______________________

() C. ______________________

() D. ______________________

TURN TO NEXT PAGE ...

ANSWERS:

- A. EXIT LIGHT OUTLET, WALL MOUNTED
- B. NIGHT LIGHT OUTLET, WALL MOUNTED
- C. JUNCTION BOX, CEILING MOUNTED
- D. NIGHT LIGHT OUTLET, CEILING MOUNTED

On the previous pages you have learned to identify various symbols that would normally appear on an electrical floor print. Let's see if you remember some of them:

IN THE SPACES PROVIDED, IDENTIFY THE COMPONENT REPRESENTED BY THE SYMBOL:

(━━━━) A. ____________________

(▬) B. ____________________

(▨) C. ____________________

(────) D. ____________________

(-------) E. ____________________

(──///──) F. ____________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

ANSWERS:
A. FEEDER

B. LIGHTING PANEL

C. POWER PANEL

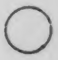
D. BRANCH CIRCUIT (CONCEALED IN CEILING OR WALL) or 2 WIRE CIRCUIT

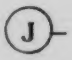
E. BRANCH CIRCUIT (EXPOSED)

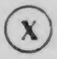
F. 3 WIRE BRANCH CIRCUIT

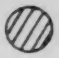
NOTE: IF YOU HAD ANY TROUBLE REMEMBERING THESE SYMBOLS, TURN BACK TO PAGE 13 AND DO A LITTLE REVIEW.

HOW ABOUT THESE?

() A. ______________________

() B. ______________________

() C. ______________________

() D. ______________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

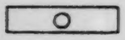
ANSWERS: A. INCANDESCENT FIXTURE OUTLET, CEILING MOUNTED

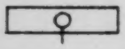
B. JUNCTION BOX, WALL MOUNTED

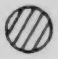
C. EXIT LIGHT OUTLET, CEILING MOUNTED

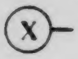
D. NIGHT LIGHT OUTLET, CEILING MOUNTED

AND SOME MORE ...

() A. ____________________

() B. ____________________

() C. ____________________

() D. ____________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

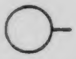
ANSWERS: A. FLUORESCENT FIXTURE OUTLET, CEILING MOUNTED

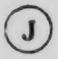
B. FLUORESCENT FIXTURE OUTLET, WALL MOUNTED

C. NIGHT LIGHT OUTLET, CEILING MOUNTED

D. EXIT LIGHT OUTLET, WALL MOUNTED

AND SOME MORE ...

() A. ______________________

() B. ______________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

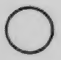
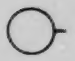
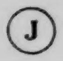
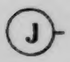
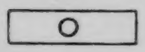
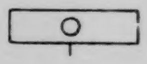
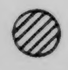
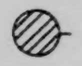
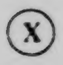
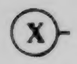
ANSWERS: A. INCANDESCENT FIXTURE OUTLET, WALL MOUNTED

B. JUNCTION BOX, CEILING MOUNTED

NOTE: IF YOU HAD ANY PROBLEM ON THE LAST THREE PAGES REMEMBERING THE NAMES OF THE SYMBOLS, GO BACK TO THE PAGES WHERE THEY WERE DISCUSSED.

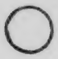
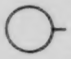
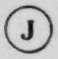
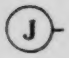
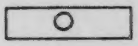
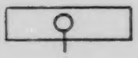
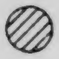
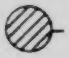
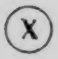
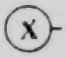
TURN TO NEXT PAGE ...

IN THE SPACES PROVIDED, DETERMINE WHAT ELECTRICAL FIXTURE THE SYMBOL REPRESENTS AND HOW IT IS MOUNTED (CEILING OR WALL):

SYMBOL	NAME
	1. ______________________
	2. ______________________
	3. ______________________
	4. ______________________
	5. ______________________
	6. ______________________
	7. ______________________
	8. ______________________
	9. ______________________
	10. ______________________

TURN TO NEXT PAGE ...

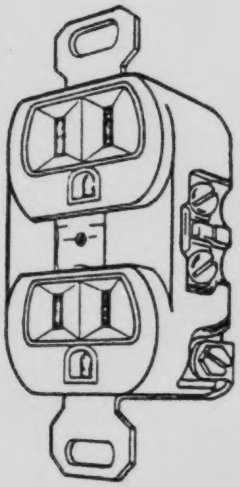
ANSWERS:

SYMBOLS	NAME
	1. Incandescent Fixture (Ceiling)
	2. Incandescent Fixture (Wall)
	3. Junction Box (Ceiling)
	4. Junction Box (Wall)
	5. Fluorescent Fixture (Ceiling)
	6. Fluorescent Fixture (Wall)
	7. Night Light Outlet (Ceiling)
	8. Night Light Outlet (Wall)
	9. Exit Light Outlet (Ceiling)
	10. Exit Light Outlet (Wall)

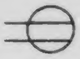
TURN TO NEXT PAGE ...

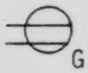
The Duplex Convenience Outlet, grounding or non-grounding, is installed on a branch circuit for the connection of an attachment plug and flexible cord of your radio, TV, and etc.

The illustration at the right is the grounding type outlet.



On a electrical print, either type maybe shown as such:

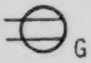
NON-GROUNDING ()

GROUNDING ()

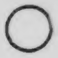
IN THE SPACE PROVIDED, IDENTIFY, BY DRAWING, THE DUPLEX CONVENIENCE OUTLET DEPICTED BY THE ILLUSTRATION:

(   )

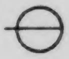
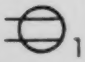
TURN TO NEXT PAGE ...

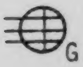
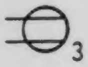
ANSWER: ()

The Amercian Standard Association has adopted the use of a basic standard symbol from which to create the other receptacle outlet symbols:

()

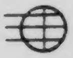
EXAMPLES:

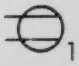
() OR (* ) SINGLE CONVENIENCE OUTLET, NON-GROUNDING TYPE

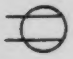
() OR (* ) TRIPLEX CONVENIENCE OUTLET, GROUNDING TYPE

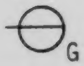
* NOTE: THIS SYMBOL MAY DENOTE A GROUNDING OR NON-GROUNDING TYPE OUTLET. YOU SHOULD CHECK LEGEND OF THE DRAWING FOR SPECIFICATIONS.

DETERMINE WHAT EACH SYMBOL REPRESENTS, AND PLACE YOUR ANSWERS IN THE SPACES PROVIDED:

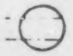
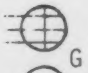
() A. ____________________

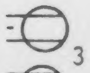
() B. ____________________

() C. ____________________

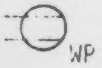
() D. ____________________

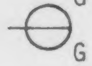
TURN TO NEXT PAGE ...

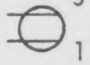
ANSWERS: A. () C. (

) OR (

)

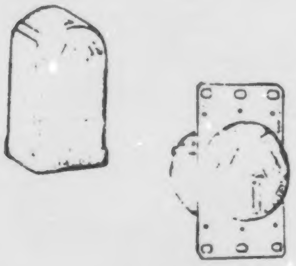
B. (

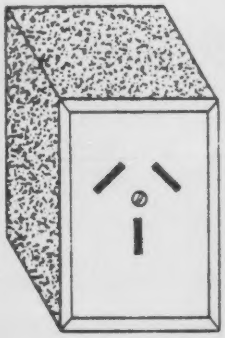
) D. (

) OR (

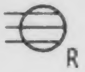
))

The illustrations below show some of the shapes and forms of a Range Convenience Outlet:



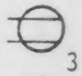


but on an electrical print the outlet has only one shape:

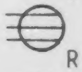
(

)

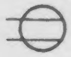
IDENTIFY THE BELOW LISTED ELECTRICAL SYMBOLS. [PLACE YOUR ANSWERS IN THE SPACES PROVIDED]:

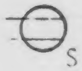
(

) A. ______________________

(

) B. ______________________

() C. ______________________

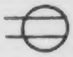
(

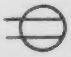
) D. ______________________

TURN TO NEXT PAGE ...

ANSWERS: A. TRIPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE
B. SINGLE CONVENIENCE OUTLET, NON-GROUNDING OR GROUNDING TYPE
C. DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE
D. SINGLE CONVENIENCE OUTLET, GROUNDING TYPE

Another method of identifying convenience outlets, other than duplex convenience outlets, is by using a capital letter instead of a number. The letter represents a type of outlet, and is usually the first letter of the type of outlet or a combination of letters.

EXAMPLES: ( WP) INDICATES A WEATHERPROOF CONVENIENCE OUTLET

( S) INDICATES A SWITCH & DUPLEX CONVENIENCE OUTLET

IN THE SPACES PROVIDED, DRAW THE ELECTRICAL SYMBOL THAT WILL REPRESENT THE CONVENIENCE OUTLETS LISTED BELOW:

A. A DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE ( )

B. A WEATHERPROOF CONVENIENCE OUTLET ( )

C. A TRIPLEX CONVENIENCE OUTLET, GROUNDING TYPE ( )

D. SINGLE CONVENIENCE OUTLET, GROUNDING TYPE ( )

TURN TO NEXT PAGE ...

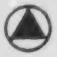
ANSWERS: A. TRIPLEX CONVENIENCE OUTLET, NON-GROUNDING OR GROUNDING TYPE

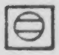
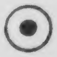
B. RANGE CONVENIENCE OUTLET

C. DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE

D. SWITCH & DUPLEX CONVENIENCE OUTLET

Two more uses of the basic standard symbol are the:

() SPECIAL PURPOSE OUTLET, NON-GROUNDING TYPE

() OR (* ) FLOOR DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE

*NOTE: THIS SYMBOL MAY DENOTE A GROUNDING TYPE OR NON-GROUNDING TYPE OUTLET. YOU SHOULD CHECK LEGEND OF THE DRAWING FOR SPECIFICATIONS.

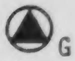
LISTED BELOW ARE THE NAMES OF SOME RECEPTACLE OUTLETS, DRAW THE SYMBOL THAT WILL REPRESENT THEM ON AN ELECTRICAL PRINT:

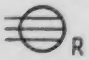
A. SPECIAL PURPOSE OUTLET, GROUNDING TYPE ( )

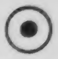
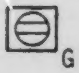
B. RANGE CONVENIENCE OUTLET ( )

C. FLOOR DUPLEX CONVENIENCE OUTLET, GROUNDING TYPE ( )

TURN TO NEXT PAGE ...

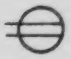
ANSWERS: A. ()

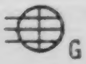
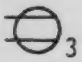
B. ()

C. () OR ()

On the previous pages you have learned to identify various symbols that would normally appear on an electrical print. Let's see if you remember some of them:

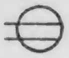
IDENTIFY THESE:

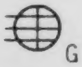
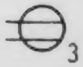
A. () ____________________

B. () OR () ____________________

TURN TO NEXT PAGE
AND CHECK YOUR ANSWERS ...

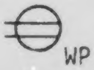
ANSWERS:

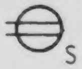
A. () DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE

B. () OR () TRIPLEX CONVENIENCE OUTLET, GROUNDING TYPE

NOTE: IF YOU HAD TROUBLE REMEMBERING, TURN TO PAGES 27 & 28.

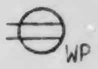
HOW ABOUT THESE:

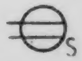
A. () ______________________________

B. () ______________________________

TURN TO NEXT PAGE
AND CHECK YOUR ANSWERS ...

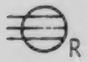
ANSWERS:

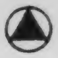
A. () WEATHERPROOF CONVENIENCE OUTLET, NON-GROUNDING TYPE

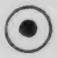
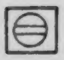
B. () SWITCH & DUPLEX CONVENIENCE OUTLET

NOTE: TROUBLE HERE? TURN TO PAGE 29.

REMEMBER THESE:

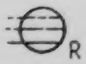
A. () ____________________

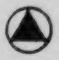
B. () ____________________

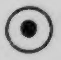
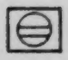
C. () OR () ____________________

TURN TO NEXT PAGE
AND CHECK YOUR ANSWERS ...

ANSWERS:

A. () RANGE CONVENIENCE OUTLET

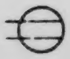
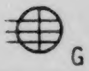
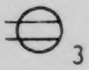
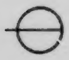
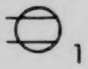
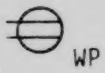
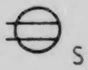
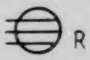
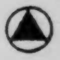
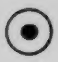
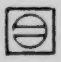
B. () SPECIAL PURPOSE OUTLET, NON-GROUNDING TYPE

C. () OR () FLOOR DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE

NOTE: IF TROUBLE HERE, TURN TO PAGES 30 & 31.

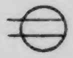
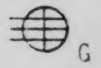
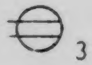
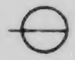
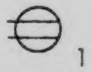
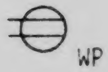
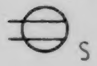
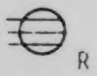
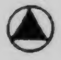
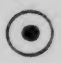
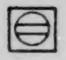
TURN TO NEXT PAGE
AND CHECK YOUR ANSWERS ...

IN THE SPACE PROVIDED, DETERMINE WHAT TYPE OF CONVENIENCE OUTLET THE SYMBOL REPRESENTS:

SYMBOL		NAME
		1. ______________________
		2. ______________________
		3. ______________________
		4. ______________________
		5. ______________________
		6. ______________________
		7. ______________________
		8. ______________________

TURN TO NEXT PAGE
AND CHECK YOUR ANSWERS ...

ANSWERS:

SYMBOL		NAME
		1. DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE.
		2. TRIPLEX CONVENIENCE OUTLET, GROUNDING TYPE.
		3. SINGLE CONVENIENCE OUTLET, NON-GROUNDING TYPE.
		4. WEATHERPROOF CONVENIENCE OUTLET, NON-GROUNDING TYPE.
		5. SWITCH & DUPLEX CONVENIENCE OUTLET
		6. RANGE CONVENIENCE OUTLET
		7. SPECIAL PURPOSE OUTLET, NON-GROUNDING TYPE.
		8. FLOOR DUPLEX CONVENIENCE OUTLET, NON-GROUNDING TYPE.

TURN TO NEXT PAGE ...

BEFORE GOING ON TO THE NEXT OBJECTIVE, LET'S REVIEW THE FIRST OBJECTIVE.

REMEMBER THESE:

SYMBOL	NAME
━━━━━━	1. ________________
■	2. ________________
▨	3. ________________
☒	4. ________________
Ⓜ	5. ________________
──────	6. ________________
══ ‒ ══ ‒ ‒ ‒ ‒ ‒	7. ________________
- - - - - - - - - - -	8. ________________
──►──►	9. ________________
──///──	10. ________________
──////──	11. ________________

TURN TO PAGE 13 FOR THE CORRECT ANSWERS. AFTER CHECKING YOUR ANSWERS GO TO PAGE 39.

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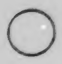
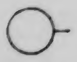
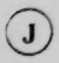
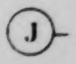
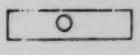
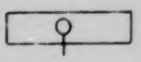
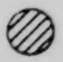
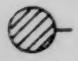
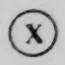
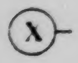
THE SYMBOLS LISTED BELOW ARE FROM THE SECOND OBJECTIVE.

TRY TO IDENTIFY THEM:

SYMBOL	NAME
	1. ____________________
	2. ____________________
	3. ____________________
	4. ____________________
	5. ____________________
	6. ____________________
	7. ____________________
	8. ____________________
	9. ____________________
	10. ____________________

TURN TO PAGE 26 FOR THE CORRECT ANSWERS. AFTER CHECKING YOUR ANSWERS GO TO PAGE 40.

For interior wiring you will use single pole, two or double pole, 3-way, or 4-way "toggle" switches. Most of the switches you use will be single pole, but occasionally you will have to install a 3-way system and on occasions a 4-way system very rarely.

The symbol for a single pole switch on an electrical print is:

(S)

By placing a number to the lower right & below the single pole switch symbol, you can differentiate between the other types of switches.

EXAMPLE: (S_2) INDICATES A TWO OR DOUBLE POLE SWITCH.

IN THE SPACES PROVIDED, DRAW THE SYMBOL OF THE REQUESTED SWITCH:

A. SINGLE POLE SWITCH ( )

B. TWO OR DOUBLE POLE SWITCH ( )

C. THREE-WAY SWITCH ( )

D. FOUR-WAY SWITCH ( )

TURN TO NEXT PAGE ...

ANSWERS: A. (S) C. (S_3)

B. (S_2) D. (S_4)

The American Standard Association utilized that basic standard symbol:

(○)

from which to create two types of switches:

A. (Ⓢ-) PULL SWITCH, WALL MOUNTED

B. (Ⓢ) PULL SWITCH, CEILING MOUNTED

C. (Ⓣ-) THERMOSTAT, USUALLY WALL MOUNTED

IN THE SPACES PROVIDED, DRAW THE ELECTRICAL SYMBOL THAT REPRESENTS THE SWITCHES LISTED BELOW:

A. 4-WAY SWITCH ( )

B. THERMOSTAT SWITCH ( )

C. PULL SWITCH, WALL MOUNTED ( )

D. 2 OR DOUBLE POLE SWITCH ( )

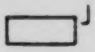
TURN TO NEXT PAGE ...

ANSWERS: A. (S_4) C. (Ⓢ—)

B. (Ⓣ—) D. (S_2)

The National Electrical Code states that an isolating switch is a switch intended for isolating an electrical circuit from the source of power. It is intended to be operated only after the circuit has been opened by some other means.

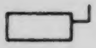
The symbol for an Isolating Switch is:

()

IDENTIFY THE SYMBOLS LISTED BELOW. [PLACE YOUR CORRECT ANSWER IN THE SPACES PROVIDED]:

(S_3) A. ______________________________

(Ⓢ) B. ______________________________

() C. ______________________________

(Ⓣ—) D. ______________________________

TURN TO NEXT PAGE ...

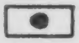
ANSWERS: A. THREE-WAY SWITCH

B. PULL SWITCH, CEILING MOUNTED

C. ISOLATING SWITCH

D. THERMOSTAT SWITCH

The final symbol you will have to learn and use is that of a push button switch. It looks like this on an electrical print:

()

IN THE SPACES PROVIDED, DRAW THE ELECTRICAL SYMBOL THAT REPRESENTS THE SWITCHES LISTED BELOW:

A. PULL SWITCH, CEILING MOUNTED ( )

B. SINGLE POLE SWITCH ( )

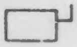
C. ISOLATING SWITCH ( )

D. PUSH BUTTON SWITCH ( )

TURN TO NEXT PAGE ...

ANSWERS: A. (Ⓢ)

B. (**S**)

C. ()

D. (⊡)

In the previous sequence, you have learned how the various types of switches are represented on electrical prints.

LET'S SEE IF YOU REMEMBER THEM :

(**S**) A. ____________________

(S_2) B. ____________________

(S_3) C. ____________________

(S_4) D. ____________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

ANSWERS: A. SINGLE POLE SWITCH

B. TWO OR DOUBLE POLE SWITCH

C. 3-WAY SWITCH

D. 4-WAY SWITCH

HOW ABOUT THESE?

(Ⓢ) A. ____________________

(Ⓢ–) B. ____________________

(Ⓣ–) C. ____________________

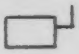
CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

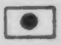
ANSWERS: A. PULL SWITCH, CEILING MOUNTED

B. PULL SWITCH, WALL MOUNTED

C. THERMOSTAT SWITCH

AND FINALLY ...

() A. ______________________________

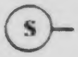
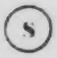
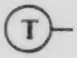
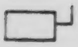
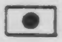
() B. ______________________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

ANSWERS: A. ISOLATING SWITCH

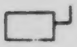
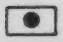
B. PUSH BUTTON SWITCH

IN THE SPACES PROVIDED, DETERMINE WHAT TYPE OF SWITCH OUTLETS THE SYMBOLS REPRESENT:

SYMBOLS	NAME
S	1. ____________________
S_2	2. ____________________
S_3	3. ____________________
S_4	4. ____________________
	5. ____________________
	6. ____________________
	7. ____________________
	8. ____________________
	9. ____________________

CHECK YOUR ANSWERS
ON THE NEXT PAGE ...

ANSWERS:

SYMBOLS	NAME
S	1. Single Pole Switch
S_2	2. Two or Double Pole Switch
S_3	3. 3-Way Switch
S_4	4. 4-Way Switch
Ⓢ—	5. Pull Switch, wall mounted
Ⓢ	6. Pull Switch, ceiling mounted
Ⓣ—	7. Thermostat Switch
	8. Isolating Switch
	9. Push Button Switch

TURN TO NEXT PAGE ...

ONE LAST ITEM, THOUGH THE SYMBOLS YOU HAVE JUST LEARNED REPRESENT A COMPONENT ON AN ELECTRICAL PRINT, IT IS REQUIRED OF THE DRAFTSMAN TO PLACE A LEGEND ON THE PRINT TO SPECIFICALLY IDENTIFY EACH SYMBOL USED ON THE DRAWING.

CONGRATULATIONS !!! YOU HAVE JUST FINISHED A VERY DIFFICULT PROGRAM. IF YOU FEEL YOU WOULD LIKE TO REVIEW THE INFORMATION FIRST BEFORE TAKING THE TEST, PLEASE DO SO.

NOTIFY THE INSTRUCTOR WHEN YOU WANT TO TAKE THE TEST.

533

SERIES: 071/590
MODULE: 00
DATE: 31 MAY 72

POLE CLIMBING TECHNIQUES

3-16

PREPARED BY:

TRAINING SUPPORT DEPARTMENT
INSTRUCTIONAL SYSTEMS DEVELOPMENT DIVISION
NAVSCON
CBC PORT HUENEME, CALIFORNIA

534

PREPARED BY: ______________________
CE-1 L. A. WILMOT, USN

REVIEWED BY: ______________________

EDITED BY: ______________________

WRITTEN AT: NAVAL SCHOOLS CONSTRUCTION
CBC PORT HUENEME, CALIFORNIA
93043

INTENDED FOR: CE school, class A training

APPROVED BY: ______________________
CDR. H. W. FILBRY, CEC, USN
COMMANDING OFFICER

887

TO THE STUDENT

Every young man, sometime in his life, has watchec a lineman working aloft and silently desired, or at least wondered, what it is like to work as a lineman. Quite often, when watching an experienced lineman, little thought is given to the knowledge and skills needed to work aloft. As a prospective lineman, you must be concerned with climbing knowledge and skill.

This is a Programmed Instruction. Correctly used, it will teach you the theory of pole climbing techniques, as outlined in the objectives on page iv. By reading these objectives, you will have a better understanding of the subjects being taught as you proceed through the program.

Programmed Instruction is a self-teaching method of instruction, and you proceed at your own pace. This program is broken down into small steps, one step per page. Each page contains a small amount of teaching material with a question or problem at the bottom. Once you have made your response to the question, you can immediately check your answer with the correct answer located at the top of the next page. If your answer is correct, continue; if your answer is incorrect, return to the previous page and reread the information and correct the error.

Since the answers to all of the questions found in this program are readily available, it would be easy to go through the program filling in the correct answers. It is obvious, however, that it would be more to your benefit to work one page at a time, in sequence, and try to answer each question before looking at the answers.

Some pages throughout the program will consist of nothing but questions. These are self-tests,and are found at the end of each objective. These will tell you if you need further study in that area.

You will be given a written test upon completion of this program. As you proceed through school, practice climbing periods will be scheduled so you can develope your climbing skills. Upon entering the Power phase, you must accomplish the terminal objective on page iv.

OBJECTIVES

UPON COMPLETION OF THIS MODULE YOU WILL BE ABLE TO:

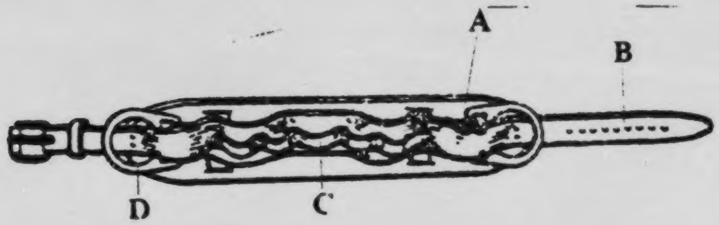
Climb to within 2 ft. of the top of a 35 ft. practice pole; maintain a three point contact and belt off at the top; circle the pole 360 degrees conterclockwise and then clockwise; while observing prescribed procedures and appropriate safety precautions.

IN ORDER TO ACCOMPLISH THIS, YOU MUST:

1. Identify, by name and purpose, the climbing equipment commonly used by a lineman.
2. Select, from a given list, the correct care and maintenance of pole climbing equipment.
3. Complete given statements pertaining to the selection, adjustment, and inspection of climbing equipment and area.
4. Select, from a given list, the statements that best describe proper climbing techniques while ascending a pole.
5. List the correct procedures, in order of occurance, for belting off on a pole.
6. List the correct procedures, in order of occurance, for circling clockwise and counterclockwise on a pole.
7. List the correct procedures, in order of occurance, for unbelting on a pole.
8. Select, from a given list, the statements that best describe proper climbing techniques for descending a pole.

TURN TO NEXT PAGE

The linesman's body belt, often called an "extra pair of hands", is divided into four basic parts. It has, (A) a cushion section which provides comfort for the lineman, (B) a belt section to secure the body belt to the lineman, (C) a tool saddle (tool loops) is provided for carrying tools, and (D) two D-rings, one on each side, to ensure a strong securing point for the safety strap.



IN THE SPACES PROVIDED BELOW, WRITE IN THE NAME OF THE BELT PART WHICH BEST FITS THE PURPOSE GIVEN.

1.______________________ provides comfort for a lineman.

2.______________________ holds tools on the body belt.

3.______________________ securing points for a safety strap.

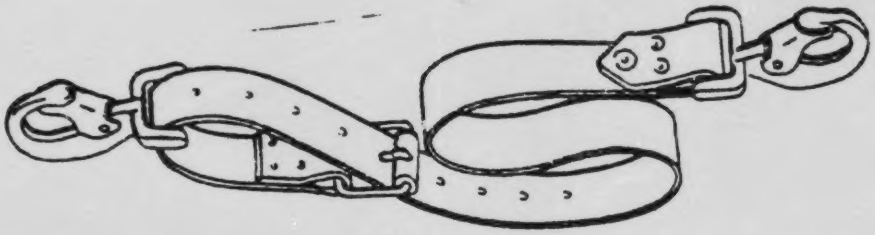
4.______________________ secures the body belt to the lineman.

TURN TO NEXT PAGE

ANSWERS:

1. THE CUSHION SECTION
2. THE TOOL SADDLE (TOOL LOOPS)
3. THE D-RINGS
4. THE BELT SECTION

The safety strap supports the lineman while he is working aloft, enabling his hands to be free. It has a snap/keeper combination at each end and a buckle assembly is provided for length adjustment.



ANSWER THE FOLLOWING QUESTIONS

1. The safety strap provides __________ for the lineman.

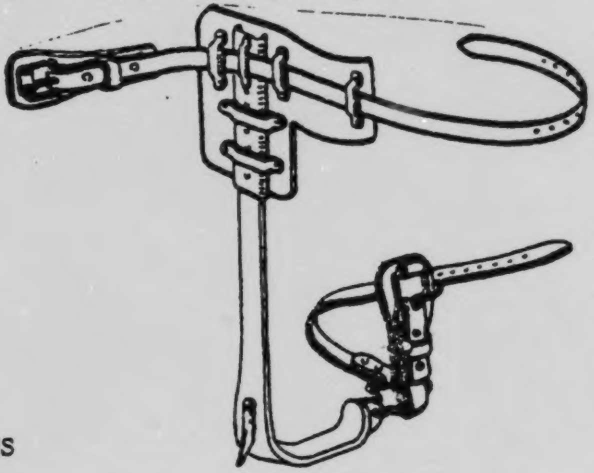
2. The body belt serves which of the following purposes? (CIRCLE THE LETTER PRECEDING THE CORRECT ANSWER).
   a. Provides comfort
   b. Carry tools
   c. Securing points for the safety strap
   d. All of the above

TURN TO NEXT PAGE

ANSWERS:

1. SUPPORT
2. ⓓ

Climbers are used to ascend, descend, and maintain a working position on a pole. Climbers are comprised of four basic parts: a steel leg iron; a gaff; an ankle strap; and leg strap.



ANSWER THE FOLLOWING QUESTIONS

1. In the spaces provided below, list the four parts of the climber.

   ______________, ______________, ______________, ______________

2. What is/are the function/s of the climber?
   (CIRCLE THE LETTER PRECEDING THE CORRECT ANSWER/S)
   a. Going up a pole
   b. Coming down a pole
   c. Maintaining a position on a pole
   d. Provides comfort on the pole.

TURN TO NEXT PAGE

ANSWERS:

1. LEG IRON, GAFF, ANKLE STRAP, LEG STRAP (IN ANY ORDER)
2. ⓐⓑⓒ

Climbing gloves protect the hands and forearms from splinters and creosote burns. Safety hats protect against impact from falling objects, accidental contact with energized conductors up to 20,000 volts, and the elements.

COMPLETE THE FOLLOWING STATEMENTS.

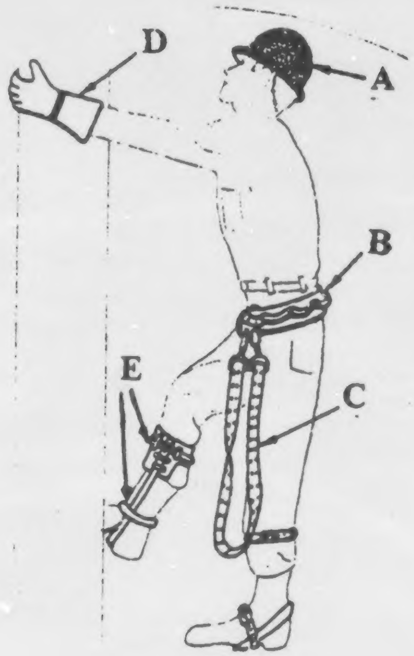
1. Protection for the lineman is provided by ____________ and ____________.
2. Climbers are used to ______________, ______________, and ______________ a working position on a pole.

TURN TO NEXT PAGE

ANSWERS:

1. GLOVES and SAFETY HAT (IN EITHER ORDER)
2. ASCEND, DESCEND (IN EITHER ORDER), MAINTAIN

ILLUSTRATED AT THE RIGHT IS A LINEMAN OUTFITTED FOR CLIMBING. LOOK IT OVER AND STUDY IT.



IN THE SPACES PROVIDED BELOW, IDENTIFY THE EQUIPMENT THAT EACH LETTER REPRESENTS, IN THE ILLUSTRATION ABOVE:

A. ______________________
B. ______________________
C. ______________________
D. ______________________
E. ______________________

TURN TO NEXT PAGE

ANSWERS:

- A. SAFETY HAT
- B. BODY BELT
- C. SAFETY STRAP
- D. GLOVES
- E. CLIMBERS

WRITE THE LETTER PRECEDING THE STATEMENTS IN COLUMN "B" IN THE APPROPRIATE SPACES IN COLUMN "A".

COLUMN A

1. Safety hat ______
2. Safety strap ______
3. Body belt ______
4. Gloves ______
5. Climbers ______

COLUMN B

- A. Ascend, descend, and maintain a working position on a pole.
- B. Gives support on a pole.
- C. Protects hands.
- D. Insulation protection up to 30,000 volts.
- E. Provides comfort and tool loops.
- F. Protection from falling objects.

TURN TO NEXT PAGE

ANSWERS:

1. F
2. B
3. E
4. C
5. A

TURN TO NEXT PAGE

Many parts of the climbing equipment are made of genuine leather and require cleaning and dressing. Leather goods should be cleaned every 3 months and dressed every 6 months. However, excessive moisture and/or perspiration may require the leather to be cleaned and dressed more frequently.

ANSWER THE FOLLOWING QUESTION

1. During a one year peroid, under normal working and weather conditions, C. E. Sailor should clean and dress his leather goods how many times?

   a. Cleaned ________ times
   b. Dressed ________ times

TURN TO NEXT PAGE

ANSWERS:

a. 4

b. 2

Cleaning, the first step in care of leather goods and synthetic products, is done with a damp sponge and a mild soap. On the item to be cleaned, work up a thick, creamy lather then rinse it with fresh water and wipe it with a dry cloth. Next, to keep leather goods soft and pliable, they are lathered well with "saddle" soap. Work the lather into the leather, then place it in the shade to dry. After the leather has nearly dried, rub it down with a soft cloth.

NOTE: SYNTHETIC PRODUCTS ARE SUBJECT TO CLEANING ONLY

ANSWER THE FOLLOWING QUESTION

1. Which of the sequences, listed below, is the correct procedure for cleaning and applying "saddle" soap to leather goods.
(CIRCLE THE LETTER PRECEDING THE CORRECT ANSWER/S)

   a. Wash it with a sponge and soap, apply saddle soap, rinse, rub it down.
   b. Wash it with a sponge and soap, rinse, dry, apply saddle soap, allow it to dry, rub it down.
   c. Wash it with a sponge and soap, rinse, apply saddle soap, rinse rub it down.

TURN TO NEXT PAGE

ANSWER:

1. ⓑ

Dressing for leather goods is done only after cleaning and saddle soaping. While the leather is still damp, apply a good leather dressing or neats-foot oil. Work the oil or dressing into the leather with your hands. Do not use an excessive amount of oil. Excess oil will saturate the leather, and weaken it. Allow the leather parts to dry in a cool, shady place for 24 hours.

NOTE: HEAT DESTROYS LEATHER

ANSWER THE FOLLOWING STATEMENT

1. In the space below, using your own words, list the correct procedure for cleaning and dressing leather goods.

TURN TO NEXT PAGE

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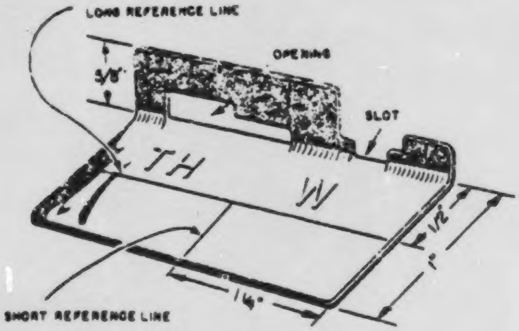
ANSWER:

1. CLEAN WITH A SPONGE AND MILD SOAP, RINSE, WIPE DRY, APPLY SADDLE SOAP, WHEN THE LEATHER IS NEARLY DRY RUB IT DOWN, APPLY DRESSING OR NEATS-FOOT OIL WHILE THE LEATHER IS DRY FOR 24 HOURS THEN RUB IT DOWN.
   (OR WORDS TO THAT EFFECT)

Gaffs, through use or damage, require filing. The amount of filing necessary is determined by checking it with a gaff gage such as illustrated below.


LONG REFERENCE LINE
OPENING
5/8"
SLOT
TH
W
1/2"
1"
1/4"
SHORT REFERENCE LINE

COMPLETE THE FOLLOWING STATEMENTS

1. Prior to dressing leather goods, they should ___________ and ___________.

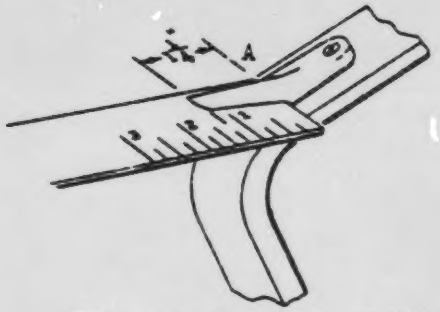
2. The amount of filing required on a gaff is determined throught the use of a _______________________.

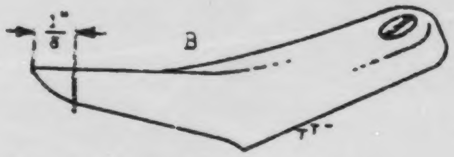
TURN TO NEXT PAGE

ANSWERS:

1. CLEAN and DAMP (IN EITHER ORDER)
2. GAFF GAGE

The gaff gage checks the gaff's width, thickness, and, on some models the length and the shape of the shoulder near the point. The length can be measured with a rule, and must be 1 1/4" minimum from the crotch to the point. (ILLUSTRATION "A") Visual checks can determine if the shoulder near the point is proper. The shoulder should be about an 1/8" back from the point. (ILLUSTRATION "B")





ANSWER THE FOLLOWING QUESTIONS. CIRCLE THE LETTER PRECEDING THE CORRECT ANSWER/S.

1. Which of the following item/s do all gaff gages measure?
   a. Width
   b. Shoulder at the point
   c. Length
   d. Thickness
   e. Gaff angle

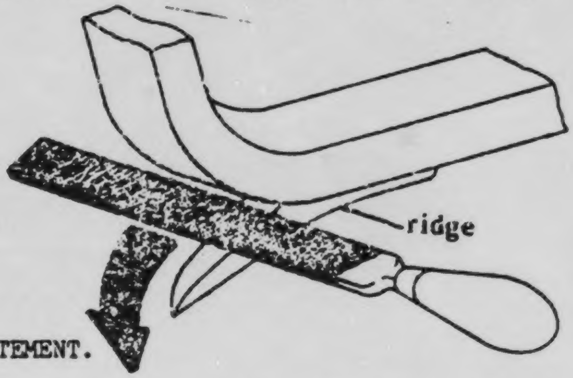
2. What is the minimim length of a gaff?
   a. 1 1/8"
   b. 2"
   c. 1 1/2"
   d. 1 1/4"

TURN TO NEXT PAGE

ANSWERS:

1. Ⓐ, Ⓓ
2. Ⓓ

Filing of the gaff, if necessary, must be done in a definite manner. The proper thickness of a gaff and the forming of the shoulder is accomplished by filing the flat underside. The filing is done in a straight line from the leg iron to the point. Width is corrected by filing the sides of the gaff in a straight line movement from the leg iron to the point. NEVER FILE THE RIDGE (BACKBONE) OF A GAFF!!



ANSWER THE FOLLOWING STATEMENT.

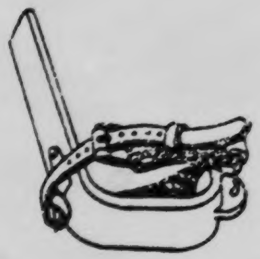
1. In your own words, state the method of filing a gaff.

TURN TO NEXT PAGE

ANSWERS:

1. GAFFS MUST BE FILED IN A STRAIGHT LINE FROM THE LEG IRON TO THE POINT.
   (OR WORDS TO THAT EFFECT)

Climbers are worn only when climbing or working on a pole. They must be removed when working on the ground. When not in use, the ankle strap should be looped around the gaff and buckled. This provides protection for the gaff and you. Climbers are to be stored in a designated area assigned by your supervisor. Equipment, properly stored, prevents accidents and adds to the life of the equipment.



ANSWER THE FOLLOWING QUESTION

1. Which of the following selections is the correct sequence to follow when you step off a pole?
   (CIRCLE THE LETTER PRECEDING THE CORRECT ANSWER/S)

   a. Walk over to the line truck, remove your gaffs, and store them in the proper place.
   b. Remove your gaffs and place them in the proper place.
   c. Remove your gaffs, make them up properly, and store them in the designated place.

TURN TO NEXT PAGE

ANSWERS:

1. [✓ C]

TURN TO NEXT PAGE

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SELECT, FROM THE FOLLOWING LIST, THE ITEMS(S) THAT IS /ARE INCLUDED IN CORRECT CARE AND MAINTENANCE OF CLIMBING EQUIPMENT. CIRCEL THE LETTER PRECEDING THE ANSWER/S.

a. Clean all leather goods.
b. Wear gaffs from one pole to another.
c. Dress leather goods with a high grade of motor oil.
d. Apply dressing only after cleaning leather goods.
e. Never file the sides of a gaff.
f. Filing is done in a straight line motion from the leg iron to the point.
g. Use a gaff gage to check the width and thickness of gaffs.
h. Clean leather goods with mild acid.
i. Apply neat-foot oil to synthetic goods.
j. The gaff ridge (backbone) is always filed.
k. Store climbers in designated places.
l. Work dressing into leather goods with a wire brush.
m. Use neats-foot oil as a leather dressing.
n. When storing climbers, use the ankle strap to protect the gaff.
o. Follow all correct care and maintenance procedures for climbing equipment.

TURN TO NEXT PAGE

ANSWERS:

Ⓐ, Ⓓ, Ⓕ, Ⓖ, Ⓚ, Ⓜ, Ⓝ, Ⓞ

TURN TO NEXT PAGE

Before using any climbing equipment - INSPECT IT - ALL OF IT!! You should check for: loose or broken rivets; cracks, nicks, stretching, dry rot, or tears in the leather; defects in snaps, hooks, buckles and D-rings; worn "leather"; and, enlarged tongue holes for belt buckles.

ANSWER THE FOLLOWING QUESTION

1. What should be done to climbing equipment prior to using it?

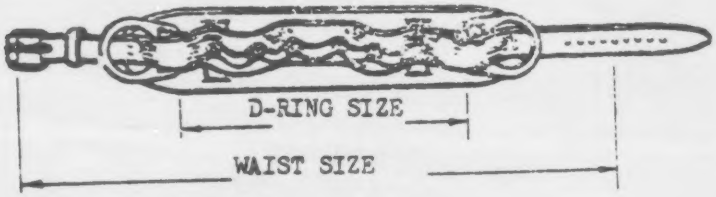
    ____

TURN TO NEXT PAGE

ANSWER:

1. INSPECTION

Body belts, like all belts, must be fitted to the individual before they can serve their purpose. Unlike other belts however, body belts have two measurements: the D-ring size, which is the distance between the D-ring heels; and the waist size, the distance between the buckle and the center hole of the tongue end.



ANSWER THE FOLLOWING QUESTION

1. The size of a body belt is determined by what factor/s?

____

TURN TO NEXT PAGE

ANSWER:

1. THE D-RING SIZE AND WAIST SIZE

When selecting a body belt, you must determine the D-ring size and the waist size you will need. Sizes are best measured with a cloth measuring tape. The D-ring size is the measured from the prominent point of your hip bone, around your back, to the prominent point on your other hip bone, plus 1". The waist size is the measurement around your body approximately 2" below the belt line. All measurements should be made over work clothes.

COMPLETE THE FOLLOWING STATEMENTS

1. The measurement made approximately 2" below the belt line is the __________ size.
2. Proper D-ring size, the distance between D-ring heels, is determined by measuring around the back from __________ to __________, plus __________.
3. Sam SeaBee measured for his D-ring size and the measurement on the tape was 35" . The correct D-ring size for Sam is __________.

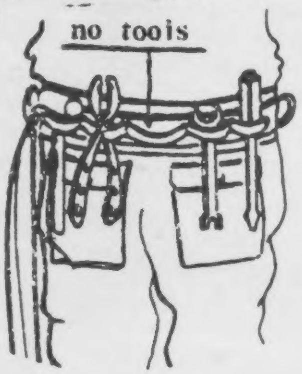
TURN TO NEXT PAGE

ANSWERS:

1. WAIST
2. PROMINENT HIP BONE to PROMINENT HIP BONE, plus 1"
3. 36"

There is a standardized relationship between the D-ring size and the waist size. However, if your measurements do not coincide with these measurements, base your selection upon your D-ring size, as waist size is adjustable.

Your body belt is worn snugly, but not too tightly, approximately 2" below your waistline with the buckle on your left side. When tools are carried in the tool loops, no tool will be placed in: tool loop directly over your spine - NEVER



COMPLETE THE FOLLOWING STATEMENTS

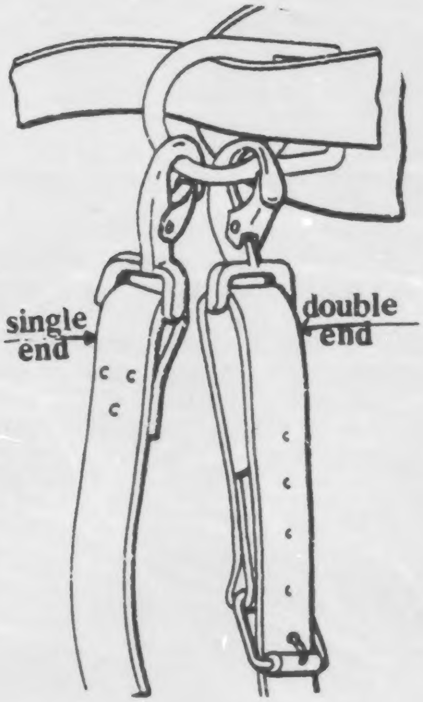
1. Final choice for body belt size should be based on ______________ measurement.
2. The body belt is worn approximately ____________ below the belt line with the buckle on the ____________ side.
3. Tools are never carried in the tool loop ____________.

TURN TO NEXT PAGE

ANSWERS:

1. D-RING
2. 2", LEFT
3. DIRECTLY OVER THE SPINE

The choice between leather or synthetic safety straps is left to the individual. When not in use, the two safety strap snaps are snapped into the same D-ring. Most right-handed men and some left-handed men carry the safety strap on the left side. However, it may be worn on the rightside. Notice in the illustration, that the double end snap is placed at the back of the D-ring with the keeper facing out; and the single end snap is placed in front of the first snap with the keeper facing in. The safety strap must be carried in this manner on the preferred side.



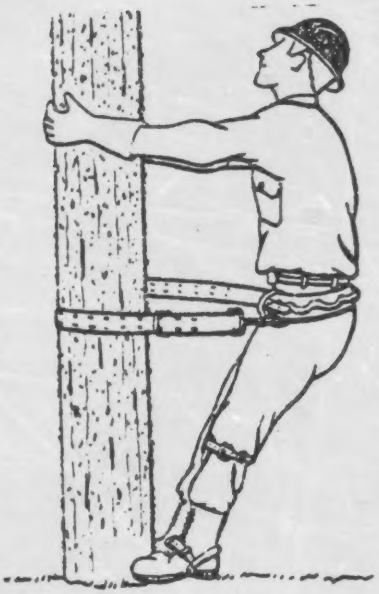
COMPLETE THE FOLLOWING STATEMENTS

1. While being carried, the keeper on the double end snap faces ________________.
2. The single end snap is placed in ______________ of the double end snap and single end snap keeper faces _______.

TURN TO NEXT PAGE

ANSWERS:

1. OUT
2. FRONT, IN



The length of the safety strap is adjusted to meet working conditions. However, there is a starting, or basic, length that can be determined for you. Standing at the base of a pole, with a body belt and safety strap on, pass the single end of the safety strap around the pole and snap it on the opposite D-ring with the keeper facing out. Place both feet against the base of the pole at a 90 degree angle and lean back, allowing the safety strap to support your body. In this position, attempt to touch your finger tips together while reaching around the pole. Adjust the safety strap until this can be accomplished.

ANSWER/COMPLETE THE FOLLOWING STATEMENTS

1. State how the starting length of a safety strap is determined.

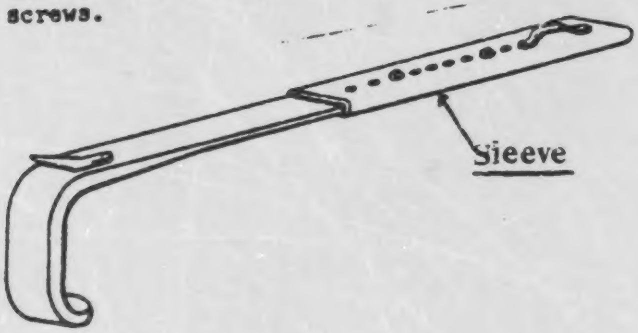
2. Once the starting length is established, it maybe adjusted to meet ____________________.

TURN TO NEXT PAGE

ANSWERS:

1. STAND, WITH BOTH FEET AT A 90 DEGREE ANGLE, AT THE BASE OF A POLE. PASS THE SAFETY STRAP AROUND THE POLE AND SNAP IT ON THE OPPOSITE D-RING. LEAN BACK, ALLOWING THE SAFETY STRAP TO HOLD YOUR WEIGHT. ADJUST THE SAFETY STRAP LENGTH UNTILL YOU CAN TOUCH YOUR FINGER TIPS TOGETHER WHILE REACHING AROUND THE POLE. (OR WORDS TO THAT EFFECT)
2. WORKING REQUIREMENTS (OR WORDS TO THAT EFFECT)

Climbers are manufactured in both fixed and adjustable lengths. When fitted properly, the leg iron will reach to about ½" below the inside prominence of the knee joint. Fixed climbers must be measured for the correct fit. Adjustable climbers may be adjusted by removing the two screws on the leg iron, sliding the sleeve up or down until the proper position is obtained and then replacing the two screws.



COMPLETE THE FOLLOWING STATEMENTS

1. The top of the leg iron should reach __________ below the ____________________.
2. Adjustable climbers use ________ screws and a sliding __________ to make various positions available.

TURN TO NEXT PAGE

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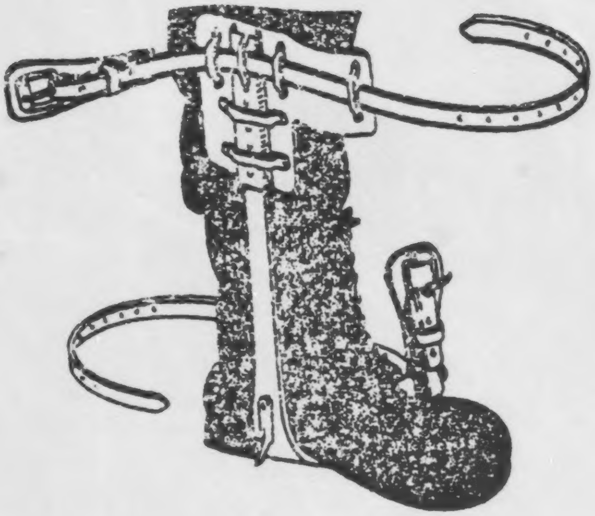
ANSWERS:

1. $\frac{1}{2}$", PROMINENCE OF THE KNEE JOINT

2. 2, SLEEVE



When fastening the climber to the leg, place the arch of the foot over the climber's saddle with the leg iron running up the inside of the leg. The ankle strap buckle must point toward the toe of the shoe and the leg strap buckle must point toward the back of the leg. If the buckles are reversed, place the climber on the other leg then check the buckles again.

NOTE: IF THE STRAPS ARE WRONG EACH TIME-----SEE YOUR SUPERVISOR

COMPLETE THE FOLLOWING STATEMENTS

1. The distinction between the left and right climber is based on the direction the _________ buckle and the _________ buckle point.

2. With the climber on the correct foot, the _________ buckle points toward the back of the leg and the _________ buckle points toward the toe of the shoe.

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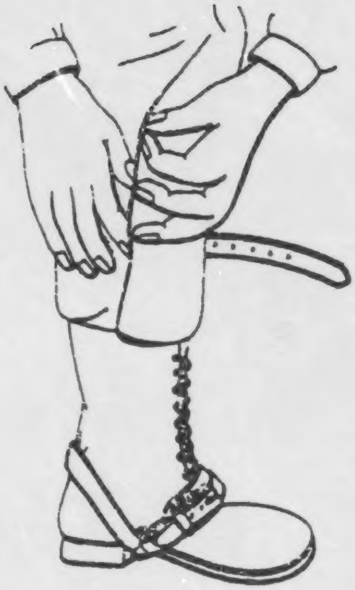
ANSWERS:

1. ANKLE STRAP, LEG STRAP (IN EITHER ORDER)
2. LEG STRAP, ANKLE STRAP

When the climber is correctly fitted to the leg, buckle the ankle strap around your ankle and the leg iron. Before buckling the leg strap, pull the pant leg up and fold it smoothly against the calf, toward the outside of the leg, to prevent binding. Ankle and leg straps should be snug, but not so tight that circulation is restricted.



NO RESPONSE REQUIRED

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Your gloves should fit snug to prevent slipping, and long sleeve shirts are a must to protect your arms. Safety hats are equipped with adjustable head bands and must be tight enough to hold the hat on your head regardless of the working position. SAFETY HATS are required to be worn at all times when you are on the pole field.

ANSWER THE FOLLOWING QUESTION

1. What is one piece of climbing equipment that must be worn at all times on the pole field?

    ____

TURN TO NEXT PAGE

ANSWER:

1. THE SAFETY HAT

Prior to climbing a pole, the pole and ground area around the pole must be inspected for safety hazzards. Remove rocks and other objects from the area around the pole. Poles should be checked for knots, nails, cracks, rotted places, ice, pole steps, and foreign objects before and while climbing.

COMPLETE THE FOLLOWING STATEMENTS

1. Climbing equipment the __________ and __________ must be inspected prior to climbing.
2. The pole should be inspected __________ and __________ climbing.

TURN TO NEXT PAGE

SELECT WORDS OR PHRASES FROM THE FOLLOWING LIST THAT BEST COMPLETE THE STATEMENTS BELOW. EACH SELECTION MAY BE USED MORE THAN ONCE. WRITE YOUR ANSWER IN THE SPACES PROVIDED.

A. 1½"
B. Working conditions
C. Knee Joint
D. Directly over the spine
E. Safety hat
F. D-ring
G. Pole
H. Inside of the leg
I. ½"
J. Distance from D-ring heel to D-ring heel
K. Front
L. 6"
M. Outside of the leg
N. Body Size
O. On the side
P. 3/4"
Q. Around
R. Inside prominence of the knee joint
S. In
T. Pole area
U. Waist
V. Out
W. Inspect it
X 2"

1. Once the starting length of the safety strap is established, it may be adjusted to meet _______________.
2. D-ring size of a body belt is the ______________________.
3. The top of the leg iron, when fitted correctly, is _____ below the __________________________ ____.
4. The body belt is worn __________ below the waist line.
5. Tools are never carried in the tool loop _______________.
6. Before using any climbing equipment, you must __________ _______________.
7. _______________ must be worn at all times on the pole field.
8. When not in use, the keeper on the double end snap of the safety strap faces _______________.
9. When determining your body belt size, the two factors taken into consideration are ___________ size and ___________ size.
10. In addition to climbing equipment, the __________ and __________ must be inspected prior to climbing.
11. When not in use, the single end snap of the safety strap is placed in __________ of the double end snap and the single end snap keeper faces ______ ___.

TURN TO NEXT PAGE

ANSWERS:

1. POLE, POLE AREA (IN EITHER ORDER)
2. BEFORE, DURING (WHILE)

TURN TO NEXT PAGE

ANSWERS:

1. WORKING CONDITIONS
2. DISTANCE FROM D-RING HEEL TO D-RING HEEL
3. ¾", INSIDE PROMINENCE OF THE KNEE JOINT
4. 2"
5. DIRECTLY OVER THE SPINE
6. INSPECT IT
7. SAFETY HAT
8. OUT
9. WAIST, D-RING (IN EITHER ORDER)
10. POLE, POLE AREA (IN EITHER ORDER)
11. FRONT, IN

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The skill involved in climbing a pole can only be gained by practice, practice, and more practice. However, this extensive practice time can be reduced by knowing and using all proven basic rules dealing with climbing positions and procedures.

TURN TO NEXT PAGE

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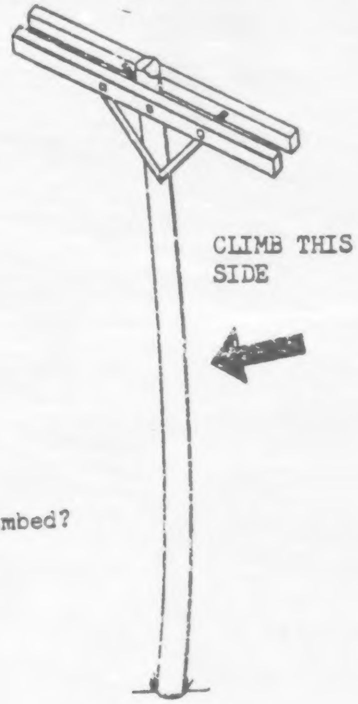
When climbing a pole you should always climb the back, or high side. The high side is the side of the pole that curves away from you when you are standing on the ground looking up at the pole.

NOTE: SOME POLES DO NOT HAVE HIGH SIDES. IN THIS CASE, THE SIDE YOU CLIMB IS UP TO YOU.



ANSWER THE FOLLOWING QUESTION.
CIRCLE THE LETTER PRECEDING THE ANSWER/S.

1. What side of a pole should be climbed?

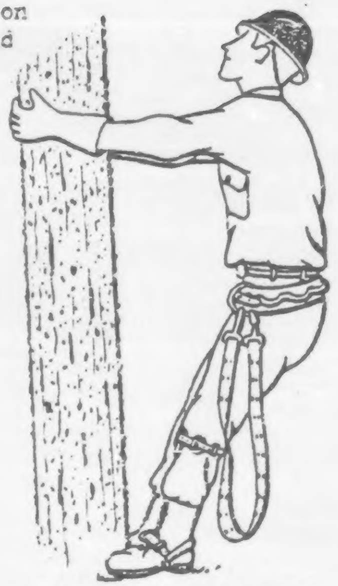
   a. High
   b. Low
   c. Face
   d. Front

TURN TO NEXT PAGE

ANSWER:

1. Ⓐ

When you are ready to start climbing, position yourself facing the high side of the pole and extend your arms around the pole until your fingertips touch. Your arms must be kept straight, not bent. Note the distance the knees and the body is from the pole. When you are climbing, MAINTAIN THE DISTANCE CLOSELY!!



ANSWER THE FOLLOWING QUESTION.

1. Once you have determined the distance you body and knees should be from the pole, what is the most important fact to remember?

____

TURN TO NEXT PAGE

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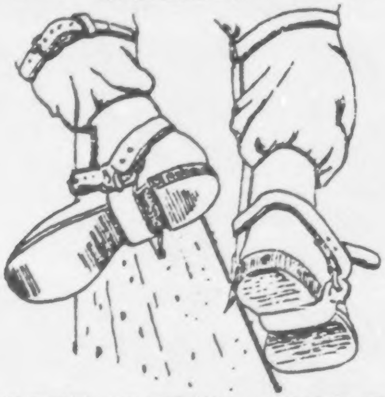
ANSWER:

1. WHILE CLIMBING, MAINTAIN THE DISTANCE CLOSELY

The gaff must be stabbed into the pole, toward the heart (center), in a downward motion similar to climbing a step ladder. Your right foot is raised, with your toe pointed away from the pole and slightly higher than your heel. By stepping downward and toward the pole, the gaff will stab into the pole near the center line.



ANSWER THE FOLLOWING QUESTION. CIRCLE THE LETTER PRECEDING THE ANSWER/S.

1. What best describes the procedure/s for sinking a gaff into a pole?

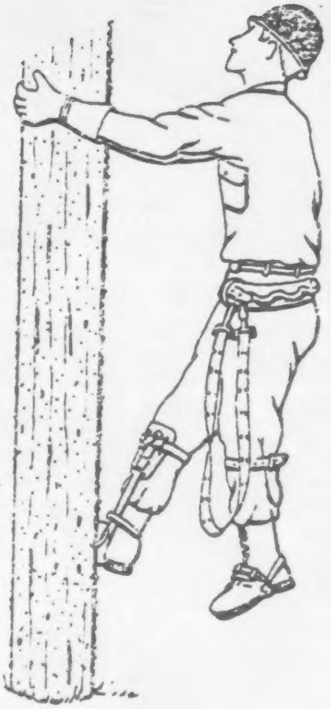
   a. Straight into the side of the pole.
   b. Downward motion, toe level with the heel.
   c. Downward motion, near the centerline.
   d. All of the above

TURN TO NEXT PAGE

ANSWER:

1. Ⓒ

With the right gaff stabbed into the pole, the lineman can swing up and rest his full weight on his right leg, locking his right knee straight. Keep the knee and the body away from the pole.



ANSWER THE FOLLOWING QUESTION.

1. What are the key factors to remember when stepping up on a stabbed in gaff?

____

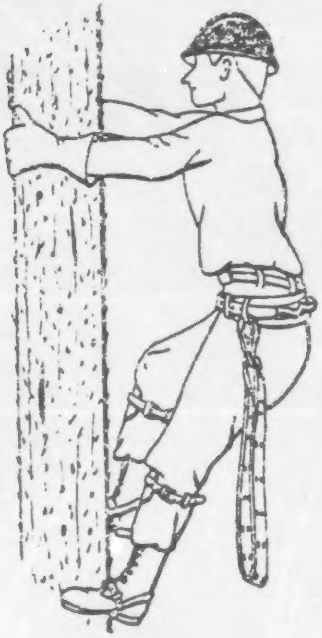
____

TURN TO NEXT PAGE

ANSWER:

1. KEEP THE KNEE STRAIGHT AND MAINTAIN THE KNEE AND BODY DISTANCE FROM THE POLE. (OR WORDS TO THAT EFFECT)

Do not climb with your arms. Let your legs do the work. Arms are used only for balance. While climbing up a pole, your legs "push" your arms. When your right leg goes up, your right arm should move up at the same time. This is the climbing rhythm method. Remember, climb with your legs.



ANSWER THE FOLLOWING QUESTIONS

1. Describe the climbing rhythm method.

2. What function do your arms serve while climbing? (CIRCLE THE LETTER PRECEDING THE ANSWER/S)
   a. Climbing
   b. Balance and climbing
   c. Balance
   d. Maintaining a step distance

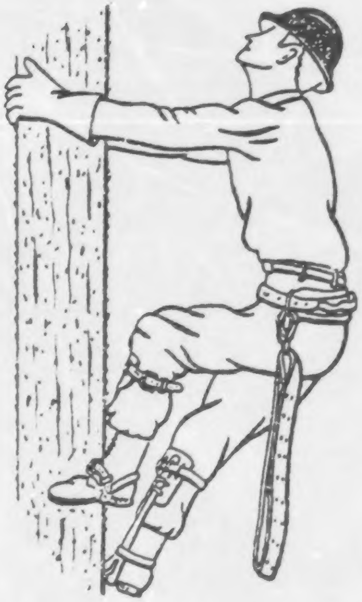
TURN TO NEXT PAGE

ANSWERS:

1. THE LEFT LEG AND ARM MOVE UP THE POLE TOGETHER AND THE RIGHT LEG AND ARM MOVE UP THE POLE TOGETHER. (IN EITHER ORDER)

2. Ⓒ

The next step is taken by raising the left leg approximately 8", aim the gaff toward the centerline of the pole, toe pointed out, and slightly higher than the heel. Then by stepping downward, the left gaff can be stabbed into the pole. The lineman then swings up onto the left leg until the left knee is locked straight. The right gaff can be broken free of the pole by twisting the toe away from the pole.



ANSWER THE FOLLOWING QUESTION

1. What is the approximate height of the step up?

____

TURN TO NEXT PAGE

ANSWER:

1. 8"

The stepping up and locking stiff-legged procedure is continued until the lineman reaches the desired height.
Don't forget the rhythm: right leg and arm move up together, left leg and arm move up together.
Maintain the knee and body distance from the pole.

TURN TO NEXT PAGE

FROM THE LIST OF STATEMENTS BELOW, SELECT THE STATEMENTS THAT BEST DESCRIBE PROPER CLIMBING PROCEDURES AND/OR RULES. CIRCLE THE LETTER PRECEDING THE ANSWER/S.

a. Sink the gaff into the sides of the pole.
b. Use the climbing rhythm method.
c. Climb with your hands
d. Maintain the knee and body distance from the pole.
e. Use your hands for balance only.
f. Keep your knee locked straight after you have stepped up on that leg.
g. Use a downward motion to sink the gaff into the pole.
h. Take approximately 8" steps.
i. Keep your knees close to the pole.
j. Climb the low side of the pole.
k. Climb the high side of the pole.

TURN TO NEXT PAGE

ANSWERS:

ⓑ, ⓓ, ⓔ, ⓕ, ⓖ, ⓗ, ⓚ

TURN TO NEXT PAGE

Once the lineman has reached the desired working height, he must "belt off". "Belting off" means fastening the safety strap around the pole so the safety strap can hold the body weight, this frees the hands for working. Again, there are proven procedures for accomplishing this feat, and strict observance of those procedures must be followed to insure your safety

NOTE: THE FOLLOWING PROCEDURES ARE WRITTEN WITH THE LINEMAN, WHO WEARS HIS SAFETY STRAP ON THE LEFT SIDE, IN MIND. THOSE WHO WEAR THE SAFETY STRAP ON THE RIGHT SIDE MUST MENTALLY INSERT THE WORD "RIGHT" WHERE "LEFT" IS WRITTEN AND "LEFT" WHERE "RIGHT" IS WRITTEN.

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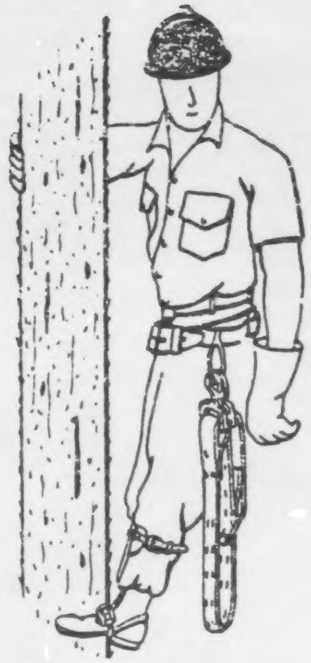


After reaching the working height, the "belting off" procedure is as follows: Both feet should be at or near the same level. The right arm is hooked around the pole until the forearm is balancing the body, with the right hand free. Remember, keep the knees and hips away from the pole! This is accomplished by bending at the waist.

ANSWER THE FOLLOWING STATEMENT:

1. State the first two steps of the belting off procedure.

Step 1. ______________________________

Step 2. ______________________________

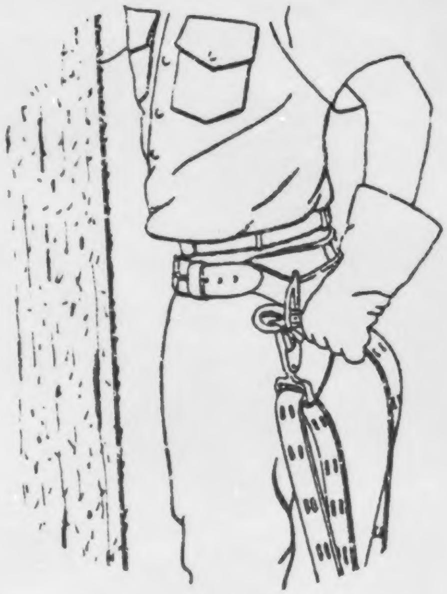
TURN TO NEXT PAGE

ANSWER:

1. STEP 1. BOTH FEET AT OR NEAR THE SAME LEVEL.
   STEP 2. RIGHT FOREARM BALANCING THE BODY, WITH THE RIGHT HAND FREE.

   (OR WORDS TO THAT EFFECT)

Once in a 3 point contact; one hand and two gaffs engaged on the pole, the lineman can proceed to the next step. Drop the left hand down and unsnap the single end snap of the safety strap. Using the left index finger to depress the keeper on the snap, it is easy to remove the snap from the D-ring.



ANSWER THE FOLLOWING STATEMENT:

1. State the first three steps of the belting off procedure.

   Step 1. ____
   ____
   Step 2. ____
   ____
   Step 3. ____
   ____

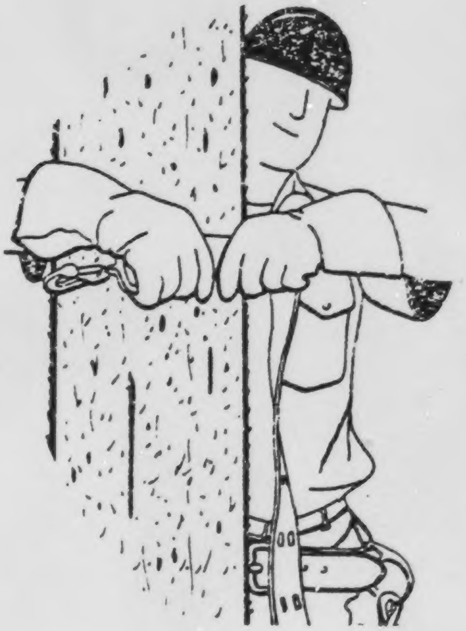
TURN TO NEXT PAGE

ANSWER:

1. STEP 1. BOTH FEET AT OR NEAR THE SAME LEVEL.
   STEP 2. RIGHT FOREARM BALANCING THE BODY, WITH THE RIGHT HAND FREE.
   STEP 3. UNSNAP THE SINGLE END SNAP OF THE SAFETY STRAP WITH THE LEFT HAND.

   (OR WORDS TO THAT EFFECT)

Pass the snap to the right hand. Then balance the body with the left hand and pull the safety strap around the pole with the right hand. The strap must not be twisted or turned. Notice in the illustration that the right hand is held palm down and the snap is placed between the thumb and index finger into the palm.



ANSWER THE FOLLOWING STATEMENT:

1. With the safety strap unsnapped and still in the left hand, state the next 3 steps of the belting off procedure.

   Step 4. ______________________________

   Step 5. ______________________________

   Step 6. ______________________________

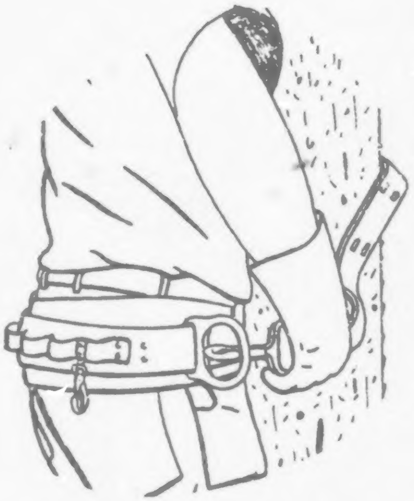
TURN TO NEXT PAGE

ANSWERS:

1. STEP 4. PASS THE SNAP TO THE RIGHT HAND.
   STEP 5. BALANCE THE BODY WITH THE LEFT HAND.
   STEP 6. PULL THE SAFETY STRAP AROUND THE POLE WITH THE RIGHT HAND.

   (OR WORDS TO THAT EFFECT)

After the strap is pulled around the pole, engage the snap on the right D-ring with the keeper facing out. SEE, FEEL, AND HEAR THE SNAP ENGAGE THE D-RING. The safety strap is held horizontal with the right hand and the body is eased back until the safety strap bears the weight of the body.



ANSWER THE FOLLOWING STATEMENT:

1. With the safety strap pulled around the pole and still in the right hand, state the next 3 steps of the belting off procedure.

   Step 7. ______________________________

   Step 8. ______________________________

   Step 9. ______________________________

TURN TO NEXT PAGE

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ANSWER:

1. STEP 7. ENGAGE THE SNAP ON THE RIGHT D-RING WITH THE KEEPER FACING OUT.

   STEP 8. HOLD THE SAFETY STRAP HORIZONTAL WITH THE RIGHT HAND.

   STEP 9. EASE THE BODY BACK UNTIL THE SAFETY STRAP IS HOLDING THE BODY WEIGHT.

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IN THE SPACE BELOW, LIST, IN ORDER OF OCCURANCE, THE NINE STEP PROCEDURE FOR BELTING OFF.

STEP 1. ______________________________
____

STEP 2. ______________________________
____

STEP 3. ______________________________
____

STEP 4. ______________________________
____

STEP 5. ______________________________
____

STEP 6. ______________________________
____

STEP 7. ______________________________
____

STEP 8. ______________________________
____

STEP 9. ______________________________
____

TURN TO NEXT PAGE

ANSWERS:

STEP 1. BOTH FEET AT OR NEAR THE SAME LEVEL.

STEP 2. RIGHT FOREARM BALANCING THE BODY, WITH THE RIGHT HAND FREE.

STEP 3. UNSNAP THE SINGLE END SNAP OF THE SAFETY STRAP WITH THE LEFT HAND.

STEP 4. PASS THE SNAP TO THE RIGHT HAND.

STEP 5. BALANCE THE BODY WITH THE LEFT HAND.

STEP 6. PULL THE SAFETY STRAP AROUND THE POLE WITH THE RIGHT HAND.

STEP 7. ENGAGE THE SNAP ON THE RIGHT D-RING WITH THE KEEPER FACING OUT.

STEP 8. HOLD THE SAFETY STRAP HORIZONTAL WITH THE RIGHT HAND.

STEP 9. EASE THE BODY BACK UNTIL THE SAFETY STRAP IS HOLDING THE BODY WEIGHT.

(OR WORDS TO THAT EFFECT)

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Quite often, after belting off, it becomes necessary to shift clockwise or counterclockwise from the orginal position. When shifting clockwise or counterclockwise, both hands should be on the safety strap. The left hand grasps the left side and the right hand grasps the right side of the safety strap.

ANSWER THE FOLLOWING QUESTION:

1. What is the first step in circling a pole counter-clockwise or clockwise?

STEP 1. ____________________
____

TURN TO NEXT PAGE

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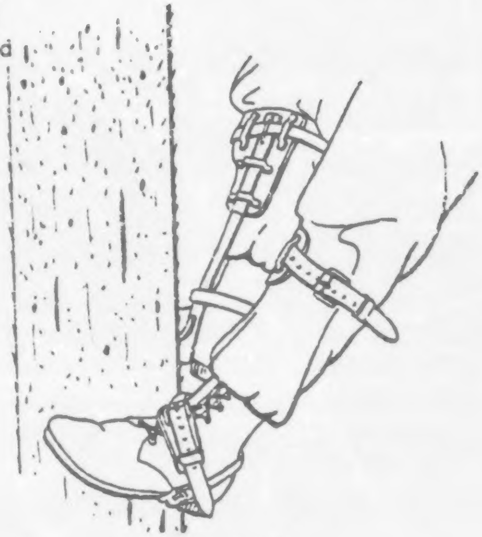
ANSWER:

1. STEP 1. BOTH HANDS SHOULD BE ON THE SAFETY STRAP.

When circling clockwise (to the left), the right gaff is stabbed into the pole approximately 4" above and 4" to the right of the left gaff. Stepping up on the right leg and pulling the left gaff loose, the body is swung to left approximately 6".



ANSWER THE FOLLOWING QUESTION:

1. When circling a pole to the left, what are the 3 steps taken after the lineman has both hands on the safety strap?

   Step 2. ______________________________

   Step 3. ______________________________

   Step 4. ______________________________

TURN TO NEXT PAGE

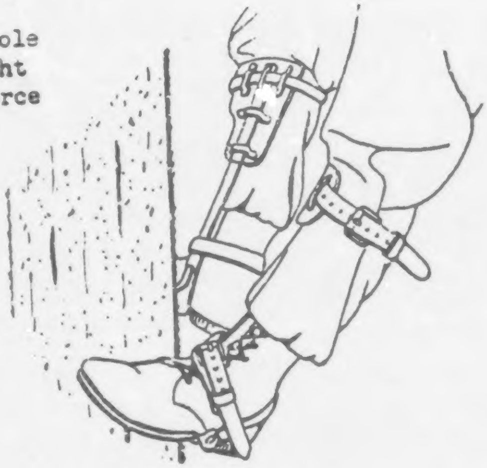
ANSWER:

1. STEP 2. STAB THE RIGHT GAFF INTO THE POLE 4" ABOVE AND 4" TO THE RIGHT OF THE LEFT GAFF.

   STEP 3. STEP UP ON THE RIGHT GAFF AND PULL THE LEFT GAFF LOOSE.

   STEP 4. SWING THE BODY 6" TO THE LEFT.

After swinging approximately 6" to the left, the lineman locks his left knee straight and bends the right knee. The left gaff is stabbed into the pole 6" to the left and 4" below the right gaff. Body weight is sufficient force to drive the gaff home.



ANSWER THE FOLLOWING QUESTION:

1. After the body is swung 6" to the left, what are the next 2 steps in circling to the left?

   Step 5. ________________________________

   Step 6. ________________________________

TURN TO NEXT PAGE

ANSWER:

1. STEP 5. LOCK THE LEFT KNEE STRAIGHT AND BEND THE RIGHT KNEE.

   STEP 6. STAB THE LEFT GAFF INTO THE POLE 6" TO THE LEFT AND 4" BELOW THE RIGHT GAFF.

As the lineman moves around the pole, he must also slide the safety strap around the pole. When moving to the left, the right hand pulls the safety strap to the right. This also helps the swing procedure.

NOTE: REPEATING THE PREVIOUS STEPS CONCERNED WITH CIRCLING THE POLE CLOCKWISE, THE LINEMAN CAN REACH THE DESIRED POSITION AND PROCEED TO DO THE ASSIGNED TASK.

ANSWER THE FOLLOWING QUESTION:

1. After the left gaff is stabbed back into the pole, what is the last step in circling a pole to the left?

   Step 7. ______________________________

   ____

TURN TO NEXT PAGE

ANSWER:

1. STEP 7. THE RIGHT HAND PULLS THE SAFETY STRAP TO THE RIGHT.

Circling the pole counterclockwise is accomplished by following the 7 steps for circling clockwise except all rights are lefts and all lefts are rights.

ANSWER THE FOLLOWING QUESTION:

1. Stab the left gaff into the pole 6" to the left and 4" below the right gaff is step 6 of circling a pole clockwise. How would step 6 read if it was written for circling counterclockwise?

   ____

   ____

TURN TO NEXT PAGE

ANSWER:

1. STAB THE RIGHT GAFF INTO THE POLE 5" TO THE RIGHT AND 4" BELOW THE LEFT GAFF.

TURN TO NEXT PAGE

ANSWER THE FOLLOWING STATEMENT AND QUESTION:

1. IN THE SPACE BELOW, LIST, IN ORDER OF OCCURANCE, THE SEVEN STEP PROCEDURE FOR CIRCLING A POLE CLOCKWISE,

STEP 1. ______________________________

____

STEP 2. ______________________________

____

STEP 3. ______________________________

____

STEP 4. ______________________________

____

STEP 5. ______________________________

____

STEP 6. ______________________________

____

STEP 7. ______________________________

____

2. WHAT IS THE DIFFERENCE BETWEEN CIRCLING A POLE COUNTER-CLOCKWISE AND CLOCKWISE?

____

____

TURN TO NEXT PAGE

ANSWERS:

1. STEP 1. BOTH HANDS SHOULD BE ON THE SAFETY STRAP.

   STEP 2. STAB THE RIGHT GAFF INTO THE POLE 4" ABOVE AND 4" TO THE RIGHT OF THE LEFT GAFF.

   STEP 3. STEP UP ON THE RIGHT GAFF AND PULL THE LEFT GAFF LOOSE.

   STEP 4. SWING THE BODY 6" TO THE LEFT.

   STEP 5. LOCK THE LEFT KNEE STRAIGHT AND BEND THE RIGHT KNEE.

   STEP 6. STAB THE LEFT GAFF INTO THE POLE 6" TO THE LEFT AND 4" BELOW THE RIGHT GAFF.

   STEP 7. THE RIGHT HAND PULLS THE SAFETY STRAP TO THE RIGHT.

2. THE PROCEDURE IS THE SAME EXCEPT THAT ALL RIGHTS ARE LEFTS AND ALL LEFTS ARE RIGHTS.

TURN TO NEXT PAGE

Having completed the task aloft, the lineman must unbelt and descend the pole. Once again, care must be taken to ensure safety.
The left forearm balances the body and the left hand is free. Maintain the hip and knee distance from the pole.

ANSWER THE FOLLOWING STATEMENT:

1. State the first step of the unbelting procedure.

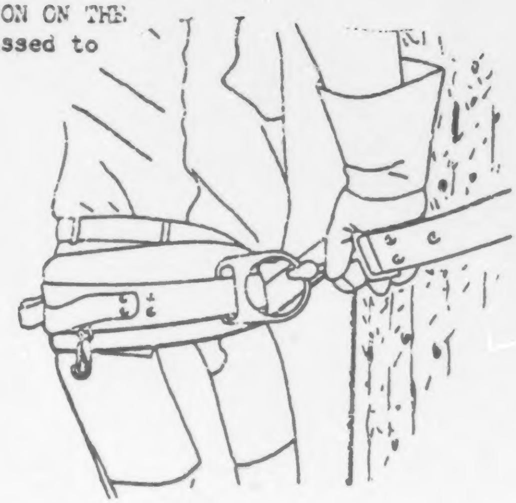
Step 1. ____________________________________
____

TURN TO NEXT PAGE

ANSWER:

1. STEP 1. THE LEFT FOREARM BALANCES THE BODY AND THE LEFT HAND IS FREE.

The right hand is dropped to the right D-ring and unsnaps the safety strap. The hand must be rotated counterclockwise so the thumb can depress the keeper. (SEE ILLUSTRATION ON THE RIGHT) The safety strap is then passed to the left hand.



ANSWER THE FOLLOWING STATEMENT:

1. Number the following 3 steps as they would occur in the unbelting procedure.

Step _____ Pass the safety strap to the left hand.

Step _____ The left forearm balances the body and the left hand is free.

Step _____ The right hand unsnaps the safety strap.

TURN TO NEXT PAGE

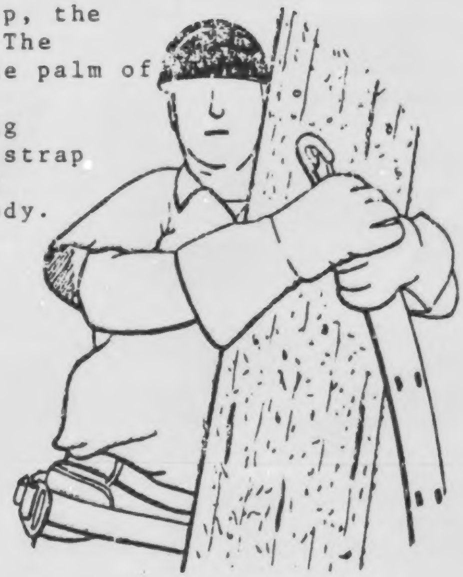
ANSWER:

1. STEP 3

STEP 1

STEP 2

When receiving the safety strap, the left hand is held palm down. The safety strap is placed into the palm of the left hand with the keeper facing up and the snap pointing toward the lineman. Once the strap is in the left hand, the right hand is used to balance the body.



ANSWER THE FOLLOWING QUESTION:

1. What is the next step after passing the safety strap to the left hand?

Step 4. ______________________________

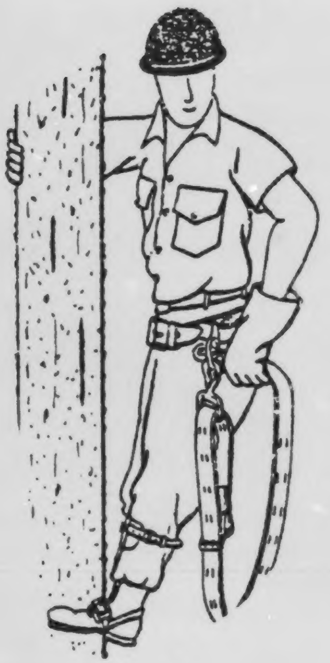
____

TURN TO NEXT PAGE

ANSWER:

1. STEP 4. USE THE RIGHT HAND TO BALANCE THE BODY.

Once the right hand is balancing the body, the left hand can carry the strap around the pole, back to the left side D-ring, and engage the snap. The snap, with the keeper facing in, is engaged in front of the other snap. Both snaps should now be back in their original position.



ANSWER THE FOLLOWING QUESTION:

1. What are the next two steps taken after passing the strap to the left hand?

Step 4. ______________________

Step 5. ______________________

TURN TO NEXT PAGE

ANSWERS:

1. STEP 4. USE THE RIGHT HAND TO BALANCE THE BODY.

   STEP 5. ENGAGE THE SNAP ON THE LEFT D-RING.

TURN TO NEXT PAGE

IN THE SPACE BELOW, LIST, IN ORDER OF OCCURANCE, THE FIVE STEP PROCEDURE FOR UNBELTING.

STEP 1. ______________________________

____

STEP 2. ______________________________

____

STEP 3. ______________________________

____

STEP 4. ______________________________

____

STEP 5. ______________________________

____

TURN TO NEXT PAGE

ANSWERS:

STEP 1. THE LEFT FOREARM BALANCES THE BODY AND THE LEFT HAND IS FREE.

STEP 2. THE RIGHT HAND UNSNAPS THE SAFETY STRAP.

STEP 3. PASS THE SAFETY STRAP TO THE LEFT HAND.

STEP 4. USE THE RIGHT HAND TO BALANCE THE BODY.

STEP 5. ENGAGE THE SNAP ON THE LEFT D-RING.

TURN TO NEXT PAGE

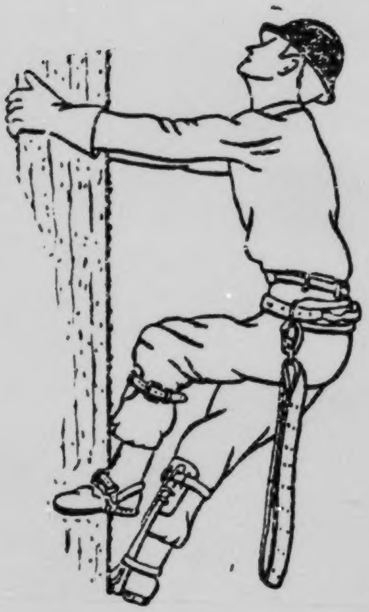
After the safety strap has been secured, the lineman is prepared to actually descend the pole.

NOTE: THE FOLLOWING SEQUENCE IS WRITTEN WITH THE RIGHT LEG TAKING THE FIRST STEP DOWN. HOWEVER, IN ACTUAL PRACTICE, YOU MAY START WITH EITHER LEG.

NO RESPONSE REQUIRED:

TURN TO NEXT PAGE

Shifting the weight to the left leg enables the lineman to disengage his right gaff from the pole. His right leg is locked straight and the right hand moves down the pole, along with the right leg. As his right hand moves down, the left knee is bent, and the right gaff is stabbed into the pole approximately 8" below and 4" to the right of the left gaff.



ANSWER THE FOLLOWING STATEMENT:

1. State how and where the right gaff is stabbed into the pole.

____
____
____
____

TURN TO NEXT PAGE

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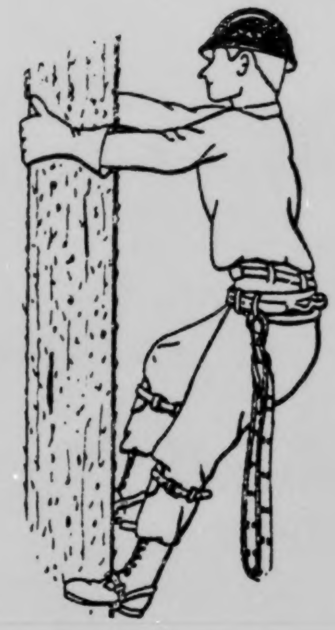
ANSWER:

1. KNEE STRAIGHT ----- 8" BELOW AND 4" TO THE RIGHT OF THE LEFT GAFF.

   (OR WORDS TO THAT EFFECT)

After the right gaff is stabbed into the pole. the left gaff can be broken free by allowing the left knee to fall away from the pole.
The left leg is then locked straight and the left hand moves down the pole, along with the left leg. The left gaff is stabbed into the pole 8" below and 4" to the left of the right gaff.



ANSWER THE FOLLOWING QUESTION:

1. Which of the following statements is/are true when descending a pole?
   (CIRCLE THE LETTER PRECEDING THE CORRECT ANSWER/S)

   a. Left hand moves down with the right hand.
   b. Right hand moves down with the left foot.
   c. Left hand moves down with the left foot.

TURN TO NEXT PAGE

ANSWER:

1. [✓ C]

The previous procedures are repeated, alternating right to left, until the lineman reaches the base of the pole.

NO RESPONSE REQUIRED

TURN TO NEXT PAGE

SELECT FROM THE FOLLOWING LIST, THE STATEMENT/S WHICH BEST DESCRIVE THE PROPER CLIMBING TECHNIQUES WHILE DESCENDING A POLE. CIRCLE THE LETTER PRECEDING THE ANSWER/S.

a. The length of the step down is approximately 6".

b. When taking a step down with the right leg, the gaff is stabbed into the pole 4" to the right and 8" below the left gaff.

c. The right hand moves up with the right foot.

d. The leg is straight when the gaff stabs into the pole.

e. The left hand moves down with the left leg.

f. The right hand moves down with the left hand.

TURN TO NEXT PAGE

ANSWER:

Ⓑ, Ⓓ, Ⓔ

TURN TO NEXT PAGE

THAT'S ALL ! ! CONGRATULATIONS ! !

Now that you have completed this program, see your learning supervisor for the Post Test on this program. After you complete the Post Test, turn this page.

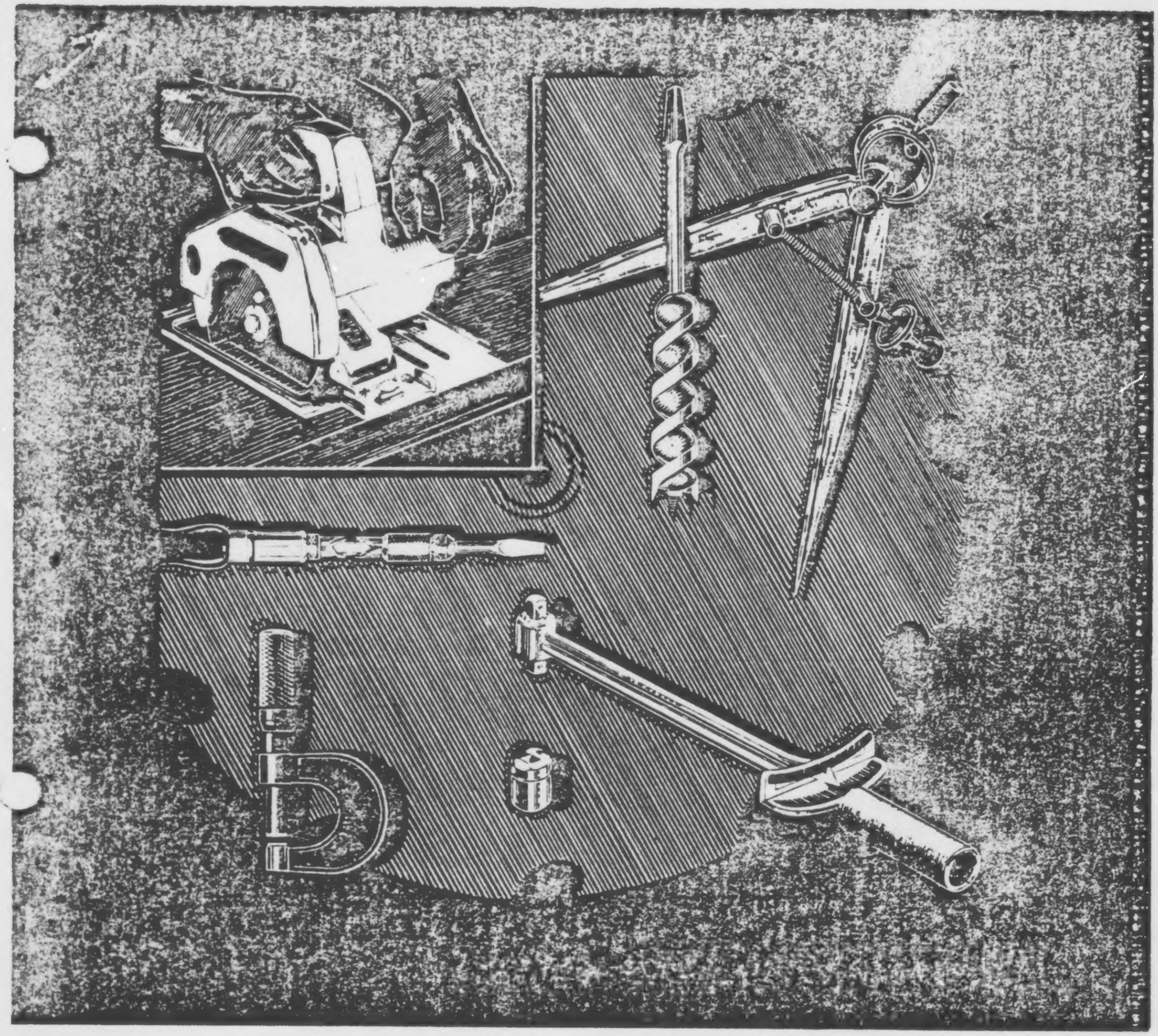
TURN TO NEXT PAGE

CONGRATULATIONS AGAIN !!!!

See your learning supervisor for the film CLI 001 "CLIMBING WITH CONFIDENCE".

As you watch this film, you will notice that some of the measurements differ with those taught in the program. However, there is a certain amount of flexability and for CE School purposes you must use our program measurements.

NOW LET'S SEE THE FILM!!



TOOLS AND THEIR USES

BUREAU OF NAVAL PERSONNEL

RATE TRAINING MANUAL NAVPERS 10085-B

PREFACE

The purpose of this manual is to provide naval personnel with an informative handbook. It contains data pertinent to a variety of tools and may be used as a supplement to other training manuals.

The satisfactory performance of modern technical equipment used by the Navy depends, to a great extent, upon adherence to approved maintenance procedures and the proper use of the correct tools.

The objectives of this manual, then, are to aid in the maintenance effort by

(a) providing descriptions, general uses, correct operation, and approved maintenance procedures for those handtools and power tools commonly used in the Navy.

(b) indoctrinating all personnel engaged in maintenance work with the importance of good workmanship.

(c) preventing and minimizing personal injury and equipment damage by emphasizing good safety practices.

Upon completion of this manual, you should be able to identify tools and fastening devices by their correct names; cite the specific purposes and uses of each tool; describe the correct operation, care and maintenance required to keep the tools in proper operating condition; and finally, perform accurate measurements.

Chapter 1 describes impact tools (hammers, mallets, and sledges), twisting and turning tools (wrenches and screwdrivers), woodcutting tools (wood saws, planes, wood chisels), metal cutting tools (chisels, dies, drills, files, hacksaws, punches, reamers, taps), holding tools (clamps, pliers, and vises), miscellaneous tools (knives, mechanical fingers, inspection mirrors), safety equipment (gloves, goggles, hard hats), and safety rules.

Chapter 2 describes pneumatic and electrically powered tools. Drills, sanders, grinders and scalers are some of the tools discussed.

Certain tools are especially useful for measuring purposes. For this reason, rules, tapes, calipers, micrometers and squares, together with techniques for using them are placed in Chapter 3.

Although fasteners are not properly classified as tools, they are used extensively with tools. Chapter 4 describes such fasteners as bolts, cotter pins, nails, nuts, rivets, screws, special speed fasteners (Dzus and Camloc types), and several methods for safetying some of these components.

Chapter 5 discusses abrasive wheels and methods for grinding and sharpening chisels, drills, punches, and snips.

Metal cutting operations using the chisel, drill, reamer and several types of thread cutters are described in Chapter 6.

The final chapter describes miscellaneous tasks the student may encounter. These include bending and flaring tubing, removing broken bolts, studs and taps, stripping insulated wire, and several soldering techniques and lubrication procedures.

As one of the Navy Training Manuals, this book was prepared by the Training Publications Division, Naval Personnel Program Support Activity, Washington, D.C., for the Bureau of Naval Personnel.

Special assistance has been rendered by various Navy personnel specially cognizant of the handtools and portable power tools used, and the work operations in which they are chiefly employed.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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SUGGESTIONS FOR USING THIS BOOK

Many people do not know how to study. The following suggestions might improve your study habits and enable you to learn more from this book.

- Set up a regular study plan. It will probably be easier for you to stick to a schedule if you can plan to study at the same time each day. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.
- Before you begin to study any part of the training manual intensively, become familiar with the entire book. Read the preface and the table of contents. Check through the index. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.
- Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the book. As you look through the book in this way, ask yourself some questions: What do I need to learn about this? What do I already know about this? How is this information related to information given in other chapters? How is this information related to the qualifications for advancement in rating?
- When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.
- In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.
- As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.
- When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Ask one of your senior petty officers or shipmates for assistance. Without looking at the training manual, write down the main ideas that you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, the chances are that you have not really mastered the information.
- Think of YOUR future as you study Navy Training Manuals. You are working for advancement to third class or second class right now, but someday you will be working toward higher rates. Anything extra that you can learn now will help you both now and later.

- If you desire information about a specific tool or operation, simply refer to the index at the alphabetical end of the book and then turn to the pages to which you are directed by that index.

Always keep in mind that a knowledge of the tools and their fundamental uses is the preliminary step in mastering the basic handtool skills. The next step is careful practice until you have mastered the various skills involved. The end result must be that you become capable of performing required operations, and of meeting the standards established in your rating qualifications. To accomplish this final result, you must first STUDY the tools and skills; then, you must PRACTICE the skills; and finally, you must DEMONSTRATE the skills.

CHAPTER 1

COMMON HANDTOOLS

Tools are designed to make a job easier and enable you to work more efficiently. Tools are a craftsman's best friend. (A craftsman is a master of any one of a number of trades such as a machinist, carpenter, hull technician, builder, or steelworker.) If the tools are not used properly or cared for, their advantages will be lost. Without them a craftsman is as helpless as he would be without his eyes. In fact, he would be more helpless, for a blind mechanic or craftsman skilled in the use of good tools and having them available, can do more than the most expert mechanic without tools.

Regardless of the type of work to be done, a craftsman must have, choose, and use the correct tools in order to do his work quickly, accurately, and safely. Without the proper tools and the knowledge of how to use them, he wastes time, reduces his efficiency, and may even injure himself. This chapter explains the specific purposes, correct use, and proper care of the more common tools you may encounter in your Navy career.

THE MOST VALUABLE TOOLS IN THE WORLD

What would you pay for THE MOST VALUABLE TOOLS IN THE WORLD? These tools can help you grip, grasp, push, twist and help you operate equipment. Furthermore, these remarkable tools can distinguish temperature variations and are sensitive to touch. It is impossible to purchase such tools . . . they are your HANDS.

These fabulous tools are subject to injury by being caught in machines, crushed by objects, or cut by a variety of sharp edged tools such as chisels, knives, or saws. Additionally, your hands can be damaged by being burnt, fractured or sprained unless you are always alert.

Why? Because they cannot THINK for themselves. PROTECT THEM. They are invaluable. KEEP ALERT while you work. THINK as you work. THINK before you make adjustments to machinery. Has the electric power been turned off? Are the required guards on the machinery? Is the object on which you are going to work properly secured and clamped?

Protect your hands from injury as directed by the applicable safety instructions whenever you use tools. You will be working under severe handicaps without the full use of both hands. Make it a habit to FOLLOW ALL SAFETY RULES.

TEN COMMANDMENTS

Obey the ten commandments of safety:

1. LEARN the safe way to do your job before you start.
2. THINK safety, and ACT safety at all times.
3. OBEY safety rules and regulations—they are for your protection.
4. WEAR proper clothing and protective equipment.
5. CONDUCT yourself properly at all times—horseplay is prohibited.
6. OPERATE only the equipment you are authorized to use.
7. INSPECT tools and equipment for safe condition before starting work.
8. ADVISE your superior promptly of any unsafe conditions or practice.
9. REPORT any injury immediately to your superior.
10. SUPPORT your safety program and take an active part in safety meetings.

In addition to the above, there are other good tool habits which will help you perform your work more efficiently as well as safely.

TOOL HABITS

"A place for everything and everything in its place" is just common sense. You can't do an efficient, fast repair job if you have to stop and look around for each tool you need. The following rules, if followed, will make your job easier for you.

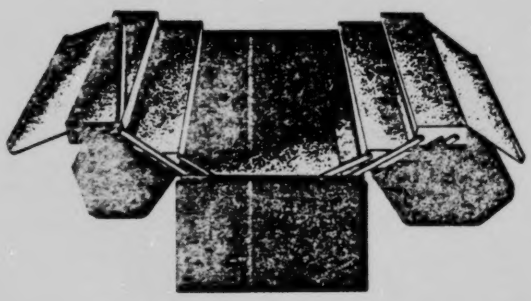
KEEP EACH TOOL IN ITS PROPER STOWAGE PLACE.—A tool is useless if you cannot find it. If you return each tool to its proper place, you'll know where it is the next time you need it.

KEEP YOUR TOOLS IN GOOD CONDITION.—Protect them from rust, nicks, burrs, and breakage.

KEEP YOUR TOOL ALLOWANCE COMPLETE.—If you are issued a tool box (fig. 1-1), each tool should be placed in it when not in use. If possible, the box should be locked and stored in a designated area. Note: Never leave the handbox adrift where it could become a missile and cause injury to personnel. An inventory list retained in the box and checked after each job will help you keep track of your tools.

USE EACH TOOL ONLY ON THE JOB FOR WHICH IT WAS DESIGNED.—If you use the wrong tool to make an adjustment, the results will probably be unsatisfactory. For example, if you use a socket wrench that's a trifle too big, you'll round off the corners of the wrench or nut. If this rounded wrench or nut is not replaced immediately the safety of your ship may be jeopardized in an emergency. Does this sound exaggerated? Remember . . . for want of a nail, a kingdom was lost.

KEEP YOUR TOOLS WITHIN EASY REACH AND WHERE THEY CANNOT FALL ON THE FLOOR OR MACHINERY.—Avoid placing tools anywhere above machinery or electrical apparatus. Serious damage will result if the tool falls into the machinery after the equipment is energized.



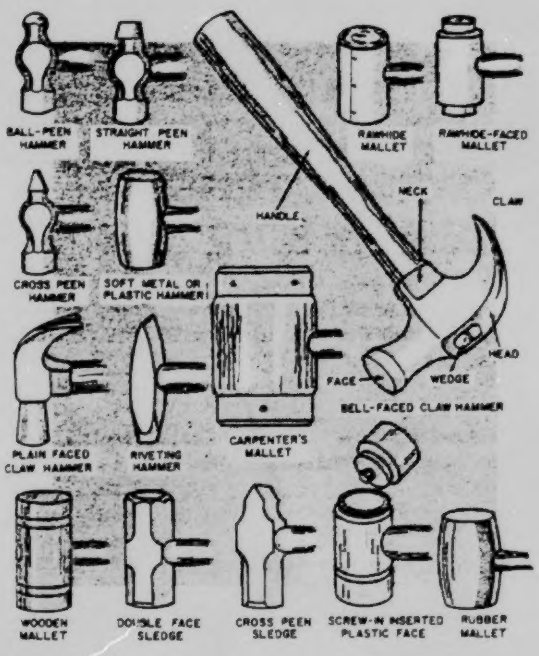
56.37(44B)

Figure 1-1.—Standard Navy toolbox.

NEVER USE DAMAGED TOOLS.—A battered screwdriver may slip and spoil the screw slot, damage other parts, or cause painful injury. A gage strained out of shape will result in inaccurate measurements.

Remember, the efficiency of a craftsman and the tools he uses are determined to a great extent by the way he keeps his tools. Likewise, he is frequently judged by the manner in which he handles and cares for them. Anyone watching a skilled craftsman at his work notices the care and precision with which he uses the tools of his trade.

The care of hand tools should follow the same pattern as for personal articles; that is, always keep hand tools clean and free from dirt, grease, and foreign matter. After use, return tools promptly to their proper place in the toolbox. Improve your own efficiency by organizing your tools so that those used most frequently can be reached easily without digging through the entire contents of the box. Avoid accumulating unnecessary junk.


BALL-PEEN HAMMER
STRAIGHT PEEN HAMMER
RAWHIDE MALLET
RAWHIDE-FACED MALLET
CROSS PEEN HAMMER
SOFT METAL OR PLASTIC HAMMER
HANDLE
NECK
CLAW
HEAD
FACE
WEDGE
BELL-FACED CLAW HAMMER
PLAIN FACED CLAW HAMMER
RIVETING HAMMER
CARPENTER'S MALLET
WOODEN MALLET
DOUBLE FACE SLEDGE
CROSS PEEN SLEDGE
SCREW-IN INSERTED PLASTIC FACE
RUBBER MALLET

5.5(44B)A

Figure 1-2.—Hammers, mallets and sledges.

STRIKING TOOLS

Hammers, mallets, and sledges are used to apply a striking force. The tool you select (fig. 1-2) will depend upon the intended application.

HAMMERS

A toolkit for nearly every rating in the Navy would not be complete without at least one hammer. In most cases, two or three are included since they are designated according to weight (without the handle) and style or shape. The shape (fig. 1-2) will vary according to the intended work. The carpenter's hammer is designed for one purpose while the machinist's hammer has other primary functions.

Carpenter's Hammer

The primary use of the carpenter's hammer is to drive or draw (pull) nails. Note the names of the various parts of the hammer shown in figure 1-2. The carpenter's hammer has either a curved or straight claw. The face may be either bell-faced or plain-faced, and the handle may be made of wood or steel. The carpenter's hammer generally used in the Navy has a curved claw, bell face, and wooden handle.

Machinist's Hammer

Machinist's hammers are mostly used by people who work with metal or around machinery. These hammers are distinguished from carpenter hammers by a variable-shaped peen, rather than a claw, at the opposite end of the face (fig. 1-2). The ball-peen hammer is probably most familiar to you.

The ball-peen hammer, as its name implies, has a ball which is smaller in diameter than the face. It is therefore useful for striking areas that are too small for the face to enter.

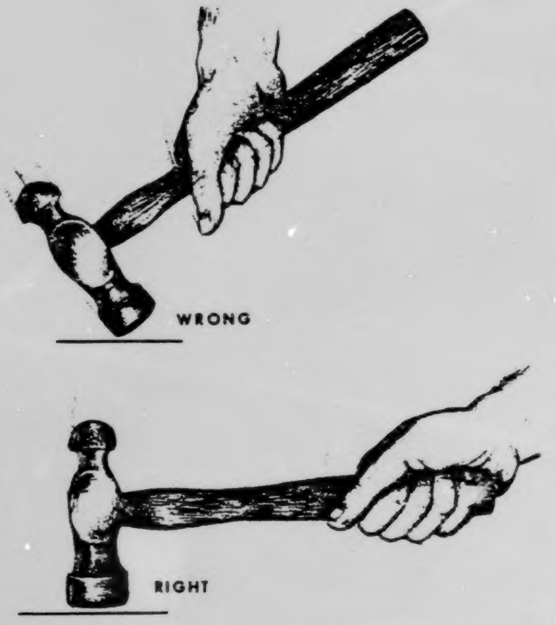
Ball-peen hammers are made in different weights, usually 4, 6, 8, and 12 ounces and 1, 1 1/2, and 2 pounds. For most work a 1 1/2-pound and a 12-ounce hammer will suffice. However, a 4- or 6-ounce hammer will often be used for light work such as tapping a punch to cut gaskets out of sheet gasket material.

Machinist's hammers may be further divided into hard-face and soft-face classifications. The hard-faced hammer is made of forged tool steel while the soft-faced hammers have a head made from brass, lead, or a tightly rolled strip of rawhide. Plastic-tipped hammers, or solid plastic with a lead core for added weight, are becoming increasingly popular.

Soft-faced hammers, (fig. 1-2) should be used when there is danger of damaging the surface of the work, as when pounding on a machined surface. Most soft-faced hammers have heads that can be replaced as the need arises. Lead-faced hammers, for instance, quickly become battered and must be replaced, but have the advantage of striking a solid, heavy nonrebounding blow that is useful for such jobs as driving shafts into or out of tight holes. If a soft-faced hammer is not available, the surface to be hammered may be protected by covering it with a piece of soft brass, copper, or hard wood.

Using Hammers

Simple as the hammer is, there is a right and wrong way of using it. (See fig. 1-3.) The most common fault is holding the handle too close to the head. This is known as choking the



5.5.1(44A)
Figure 1-3.—Right and wrong way to use a ball-peen hammer.

hammer, and reduces the force of the blow. It also makes it harder to hold the head in an upright position. Except for light blows, hold the handle close to the end to increase the lever arm and produce a more effective blow. Hold the handle with the fingers underneath and the thumb along side or on top of the handle. The thumb should rest on the handle and never overlap the fingers. Try to hit the object with the full force of the hammer. Hold the hammer at such an angle that the face of the hammer and the surface of the object being hit will be parallel. This distributes the force of the blow over the full face and prevents damage to both the surface being struck and the face of the hammer.

MALLETS AND SLEDGES

The mallet is a short-handled tool used to drive wooden-handled chisels, gouges, wooden pins, or form or shape sheet metal where hard-faced hammers would mar or injure the finished work. Mallet heads are made from a soft material, usually wood, rawhide, or rubber. For example, a rubber-faced mallet is used for knocking out dents in an automobile. It is cylindrically shaped with two flat driving faces that are reinforced with iron bands. (See fig. 1-2.) Never use a mallet to drive nails, screws, or any object that may cause damage to the face.

The sledge is a steel headed, heavy duty driving tool that can be used for a number of purposes. Short-handled sledges are used to drive bolts, driftpins, and large nails, and to strike cold chisels and small hand rock drills. Long-handled sledges are used to break rock and concrete, to drive spikes, bolts, or stakes, and to strike rock drills and chisels.

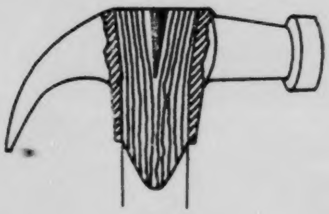
The head of a sledge is generally made of a high carbon steel and may weigh from 6 to 16 lb. The shape of the head will vary according to the job for which the sledge is designed.

MAINTENANCE OF STRIKING TOOLS

Hammers, sledges, or mallets should be cleaned and repaired if necessary before they are stored. Before using, ensure that the faces are free from oil or other material that would cause the tool to glance off nails, spikes, or stakes. The heads should be dressed to remove any battered edges.

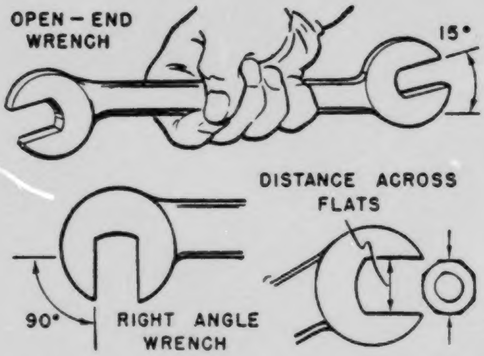
Never leave a wooden or rawhide mallet in the sun, as it will dry out and may cause the head to crack. A light film of oil should be left on the mallet to maintain a little moisture in the head.

The hammer handle should always be tight in the head. If it is loose the head may fly off and cause an injury. The eye or hole in the hammer head is made with a slight taper in both directions from the center. After the handle, which is tapered to fit the eye, is inserted in the head, a steel or wooden wedge is driven into the end of the handle that is inserted into the head. This wedge expands the handle and causes it to fill the opposite taper in the eye. Thus the handle is wedged in both directions as shown in figure 1-4. If the wedge starts to come out, it should be driven in again to tighten the handle. If the wedge comes out, replace it before continuing to use the hammer. If you cannot get another wedge right away, you may file one out of a piece of flat steel, or cut



5.5(44B)B

Figure 1-4.—Handle expanded in hammer head by wedges.



1.16.1

Figure 1-5.—Open-end wrenches.

620

one from a portion of the tang of a wornout file. The tang is the end of the file that fits into the handle.

SAFETY PRECAUTIONS

Hammers are dangerous tools when used carelessly and without consideration. Practice will help you learn to use a hammer properly.

Some important things to remember when using a hammer or mallet follow:

- Do not use a hammer handle for bumping parts in assembly, and never use it as a pry bar. Such abuses will cause the handle to split, and a split handle can produce bad cuts or pinches. When a handle splits or cracks, do not try to repair it by binding with string or wire. REPLACE IT.
- Make sure the handle fits tightly on the head.
- Do not strike a hardened steel surface with a steel hammer. Small pieces of steel may break off and injure someone in the eye or damage the work. However, it is permissible to strike a punch or chisel directly with the ball-peen hammer because the steel in the heads of punches and chisels is slightly softer than that of the hammerhead.

TURNING TOOLS (WRENCHES)

A wrench is a basic tool that is used to exert a twisting force on bolt heads, nuts, studs and pipes. The special wrenches designed to do certain jobs are, in most cases, variations of the basic wrenches that will be described in this section.

Some ratings will naturally have more use for wrenches in doing their jobs than other ratings; however, practically all ratings, including clerical, will have occasion, from time to time, to use wrenches. It is necessary, therefore, that all hands have a basic understanding of the description and uses of wrenches.

The best wrenches are made of chrome vanadium steel. Wrenches made of this material are light in weight and almost unbreakable. This is an expensive material, however, so the most common wrenches found in the Navy are made of forged carbon steel or molybdenum steel. These latter materials make good wrenches, but they are generally built a little heavier and bulkier in order to achieve the same degree of strength as chrome vanadium steel.

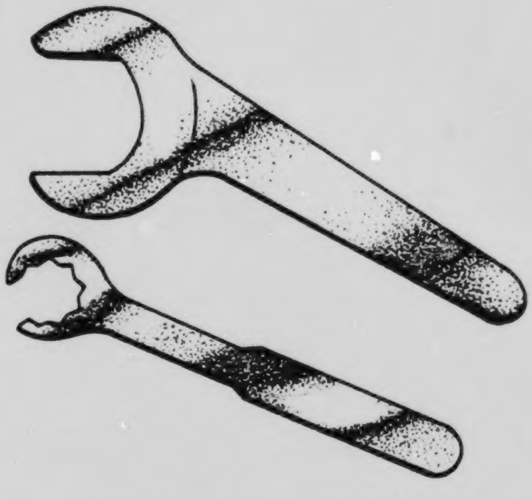
The size of any wrench used on bolt-heads or nuts is determined by the size of the opening between the jaws of the wrench. The opening of a wrench is manufactured slightly larger than the bolt head or nut that it is designed to fit. Hex-nuts (six-sided) and other types of nut or bolt heads are measured across opposite flats (fig. 1-5). A wrench that is designed to fit a 3/8-inch nut or bolt usually has a clearance of from 5 to 8 thousandths of an inch. This clearance allows the wrench to slide on and off the nut or bolt with a minimum of "play." If the wrench is too large, the points of the nut or bolt head will be rounded and destroyed.

There are many types of wrenches. Each type is designed for a specific use. Let's discuss some of them.

OPEN-END WRENCHES

Solid, nonadjustable wrenches with openings in one or both ends are called open-end wrenches. (See fig. 1-5.) Usually they come in sets of from 6 to 10 wrenches with sizes ranging from 5/16 to 1 inch. Wrenches with small openings are usually shorter than wrenches with large openings. This proportions the lever advantage of the wrench to the bolt or stud and helps prevent wrench breakage or damage to the bolt or stud. One exception exists.

Aircraft today are built in a very compact manner; and generally, many of the hydraulic



1.16(44B)A

Figure 1-6.—Hydraulic wrenches.

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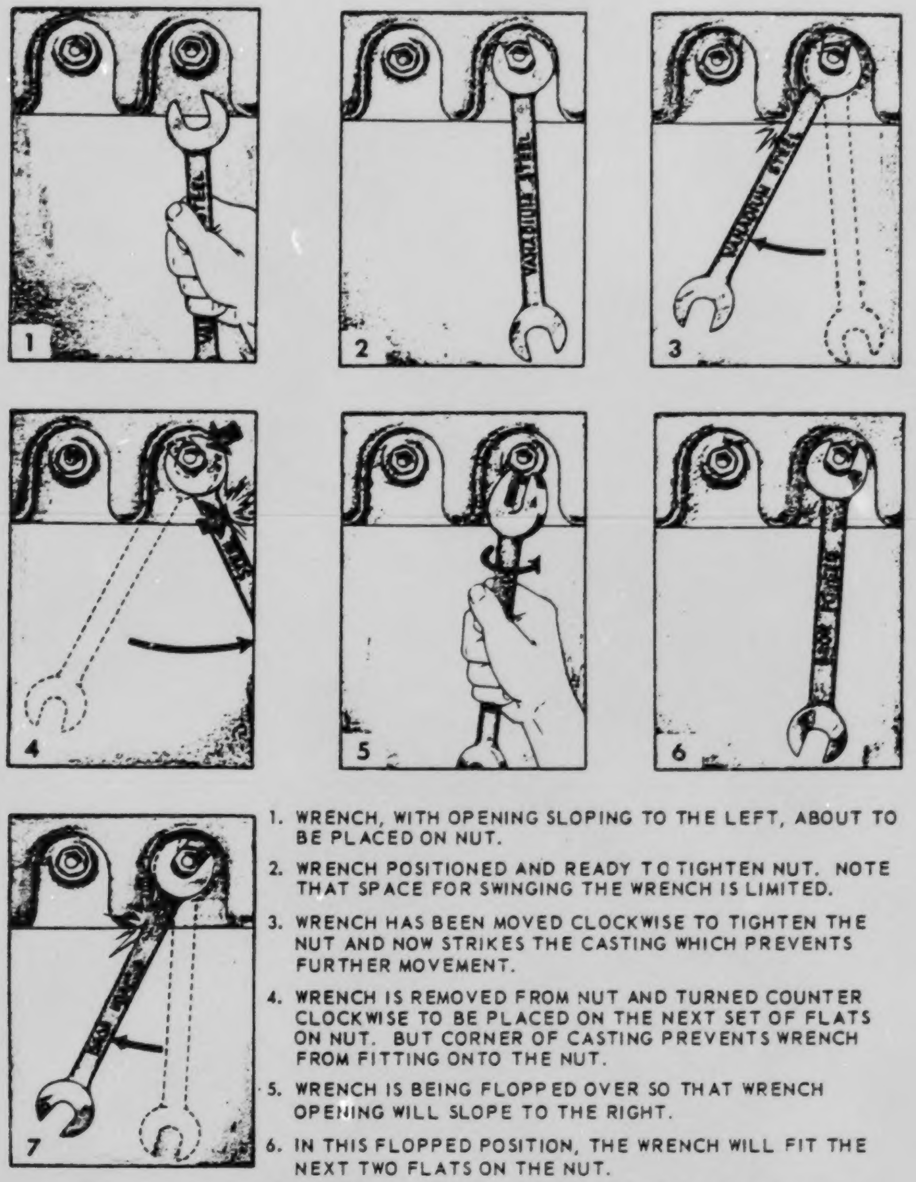


1. WRENCH, WITH OPENING SLOPING TO THE LEFT, ABOUT TO BE PLACED ON NUT.
2. WRENCH POSITIONED AND READY TO TIGHTEN NUT. NOTE THAT SPACE FOR SWINGING THE WRENCH IS LIMITED.
3. WRENCH HAS BEEN MOVED CLOCKWISE TO TIGHTEN THE NUT AND NOW STRIKES THE CASTING WHICH PREVENTS FURTHER MOVEMENT.
4. WRENCH IS REMOVED FROM NUT AND TURNED COUNTER CLOCKWISE TO BE PLACED ON THE NEXT SET OF FLATS ON NUT. BUT CORNER OF CASTING PREVENTS WRENCH FROM FITTING ONTO THE NUT.
5. WRENCH IS BEING FLOPPED OVER SO THAT WRENCH OPENING WILL SLOPE TO THE RIGHT.
6. IN THIS FLOPPED POSITION, THE WRENCH WILL FIT THE NEXT TWO FLATS ON THE NUT.
7. WRENCH NOW IS PULLED CLOCKWISE TO FURTHER TIGHTEN NUT UNTIL WRENCH AGAIN STRIKES CASTING. BY REPEATING THE FLOPPING PROCEDURE, THE NUT CAN BE TURNED UNTIL IT IS TIGHT.

1.16(44B)BX

Figure 1-7.—Use of open-end wrench.

installations are in close spaces. During certain phases of hydraulic maintenance it may be impossible to swing an ordinary wrench due to its length. Ordinary wrenches that are normally available increase in length as their size increases. Thus, when a large size wrench is needed, the length of the wrench sometimes prevents its use, due to the space available to swing the wrench. The Bonney wrench shown in figure 1-6, is an open-end wrench that may be used to great advantage due to its thickness and short length. This wrench is normally procured in the larger sizes, although it is available in a range of sizes to fit all aircraft hydraulic fittings.

Open-end wrenches may have their jaws parallel to the handle or at angles anywhere up to 90 degrees. The average angle is 15 degrees (fig. 1-5). This angular displacement variation permits selection of a wrench suited for places where there is room to make only a part of a complete turn of a nut or bolt. If the wrench is turned over after the first swing, it will fit on the same flats and turn the nut farther. After two swings on the wrench, the nut is turned far enough so that a new set of flats are in position for the wrench as shown in figure 1-7.

Handles are usually straight, but may be curved. Those with curved handles are called S-wrenches. Other open-end wrenches may have offset handles. This allows the head to reach nut or bolt heads that are sunk below the surface.

BOX WRENCHES

Box wrenches (fig. 1-8) are safer than open-end wrenches since there is less likelihood they will slip off the work. They completely surround or box a nut or bolt head.

The most frequently used box wrench has 12 points or notches arranged in a circle in the head and can be used with a minimum swing angle of 30 degrees. Six and eight point wrenches are used for heavy, 12 for medium, and 16 for light duty only.

1.16.2

Figure 1-8.—12-point box-end wrench.

One advantage of the 12 point construction is the thin wall. It is more suitable for turning nuts which are hard to get at with an open-end wrench. Another advantage is that the wrench will operate between obstructions where the space for handle swing is limited. A very short swing of the handle will turn the nut far enough to allow the wrench to be lifted and the next set of points fitted to the corners of the nut.

One disadvantage of the box-end wrench is the loss of time which occurs whenever a craftsman has to lift the wrench off and place it back on the nut in another position in case there is insufficient clearance to spin the wrench in a full circle.

COMBINATION WRENCH

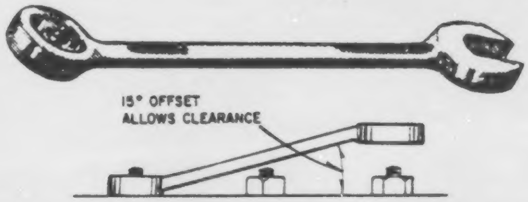
After a tight nut is broken loose, it can be unscrewed much more quickly with an open-end wrench than with a box-wrench. This is where a combination box-open end wrench (fig. 1-9) comes in handy. You can use the box-end for breaking nuts loose or for snugging them down, and the open-end for faster turning.

The box-end portion of the wrench can be designed with an offset in the handle. Notice in figure 1-9, how the 15-degree offset allows clearance over nearby parts.

The correct use of open-end and box-end wrenches can be summed up in a few simple rules, most important of which is to be sure that the wrench properly fits the nut or bolt head.

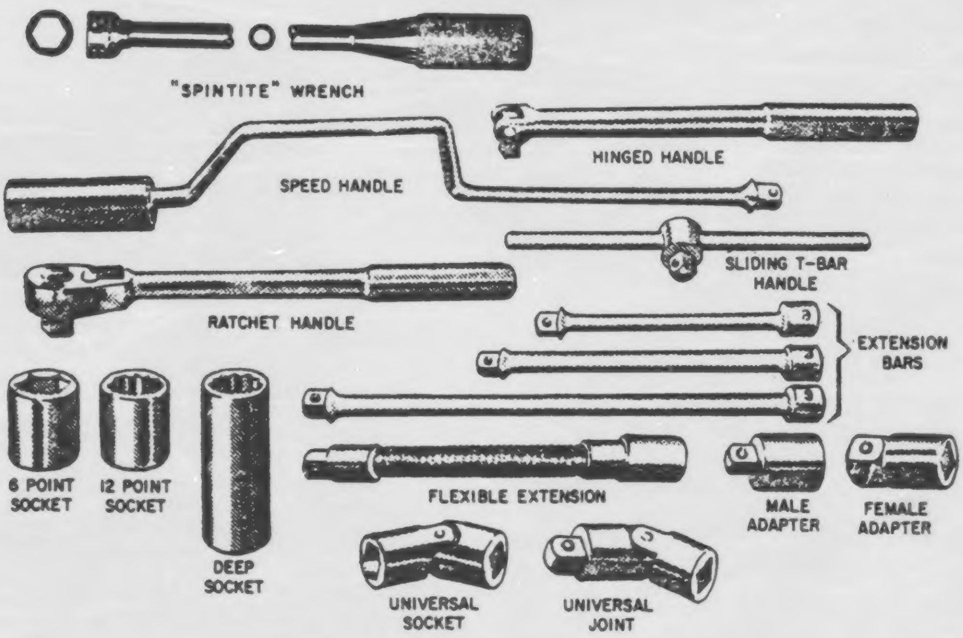
When you have to pull hard on the wrench, as in loosening a tight nut, make sure the wrench is seated squarely on the flats of the nut.

PULL on the wrench—DO NOT PUSH. Pushing a wrench is a good way to skin your knuckles if the wrench slips or the nut breaks loose unexpectedly. If it is impossible to pull



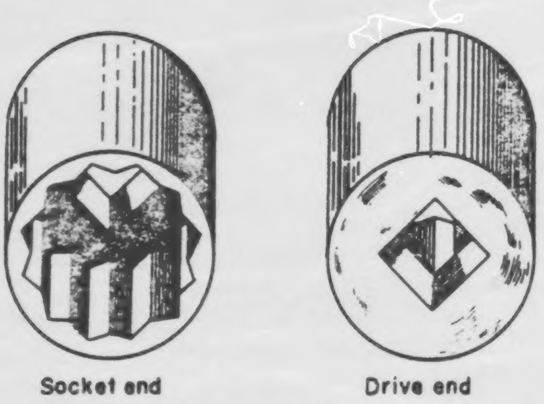
1.16.3(44B)

Figure 1-9.—Combination wrench.


"SPINTITE" WRENCH
HINGED HANDLE
SPEED HANDLE
SLIDING T-BAR HANDLE
RATCHET HANDLE
EXTENSION BARS
6 POINT SOCKET
12 POINT SOCKET
DEEP SOCKET
FLEXIBLE EXTENSION
MALE ADAPTER
FEMALE ADAPTER
UNIVERSAL SOCKET
UNIVERSAL JOINT

44.3(44B)

Figure 1-10.—Socket set components.


Socket end
Drive end

44.4

Figure 1-11.—12-point sockets.

the wrench, and you must push, do it with the palm of your hand and hold your palm open.

Only actual practice will tell you if you are using the right amount of force on the wrench. The best way to tighten a nut is to turn it until the wrench has a firm, solid "feel." This will turn the nut to proper tightness without stripping the threads or twisting off the bolt. This "feel" is developed by experience alone. Practice until you have mastered the "feel."

SOCKET WRENCH

The socket wrench is one of the most versatile wrenches in the toolbox. Basically, it consists of a handle and a socket type wrench which can be attached to the handle.

The "Spintite" wrench shown in figure 1-10, is a special type of socket wrench. It has a hollow shaft to accommodate a bolt protruding through a nut, has a hexagonal head, and is used like a screwdriver. It is supplied in small sizes only and is useful for assembly and electrical work. When used for the latter purpose, it must have an insulated handle.

A complete socket wrench set consists of several types of handles along with bar extensions, adapters, and a variety of sockets (fig. 1-10).

Sockets

A socket (fig. 1-11) has a square opening cut in one end to fit a square drive lug on a detachable handle. In the other end of the socket is a 6-point or 12-point opening very much like the opening in the box end wrench. The 12-point socket needs to be swung only half as far as the 6-point socket before it has to be lifted and fitted on the nut for a new grip. It can therefore be used in closer quarters where there is less room to move the handle. (A ratchet handle eliminates the necessity of lifting the socket and refitting it on the nut again and again.

Sockets are classified for size according to two factors. One is the size of the square opening, which fits on the square drive lug of the handle. This size is known as the drive size. The other is the size of the opening in the opposite end, which fits the nut or bolt. The standard toolbox can be outfitted with sockets having 1/4-, 3/8-, and 1/2-inch-square drive lugs. Larger sets are usually available in the toolroom for temporary checkout. The openings that fit onto the bolt or nut are usually graduated in 1/16-inch sizes. Sockets are also made in deep lengths to fit over spark plugs and long bolt ends.

Socket Handles

There are four types of handles used with these sockets. (See fig. 1-10.) Each type has special advantages, and the experienced worker chooses the one best suited for the job at hand. The square driving lug on the socket wrench handles has a spring-loaded ball that fits into a recess in the socket receptacle. This mated ball-recess feature keeps the socket engaged with the drive lug during normal usage. A slight pull on the socket, however, disassembles the connection.

RATCHET.—The ratchet handle has a reversing lever which operates a pawl (or dog) inside the head of the tool. Pulling the handle in one direction causes the pawl to engage in the ratchet teeth and turn the socket. Moving the handle in the opposite direction causes the pawl to slide over the teeth, permitting the handle to back up without moving the socket. This allows rapid turning of the nut or bolt after each partial turn of the handle. With the reversing lever in one position, the handle can be used for tightening. In the other position, it can be used for loosening.

HINGED HANDLE.—The hinged handle is also very convenient. To loosen tight nuts, swing the handle at right angles to the socket. This gives the greatest possible leverage. After loosening the nut to the point where it turns easily, move the handle into the vertical position and then turn the handle with the fingers.

SLIDING T-BAR HANDLE.—When using the sliding bar or T-handle, the head can be positioned anywhere along the sliding bar. Select the position which is needed for the job at hand.

SPEED HANDLE.—The speed handle is worked like the wood-worker's brace. After the nuts are first loosened with the sliding bar handle or the ratchet handle, the speed handle can be used to remove the nuts more quickly. In many instances the speed handle is not strong enough to be used for breaking loose or tightening the nut. The speed socket wrench should be used carefully to avoid damaging the nut threads.

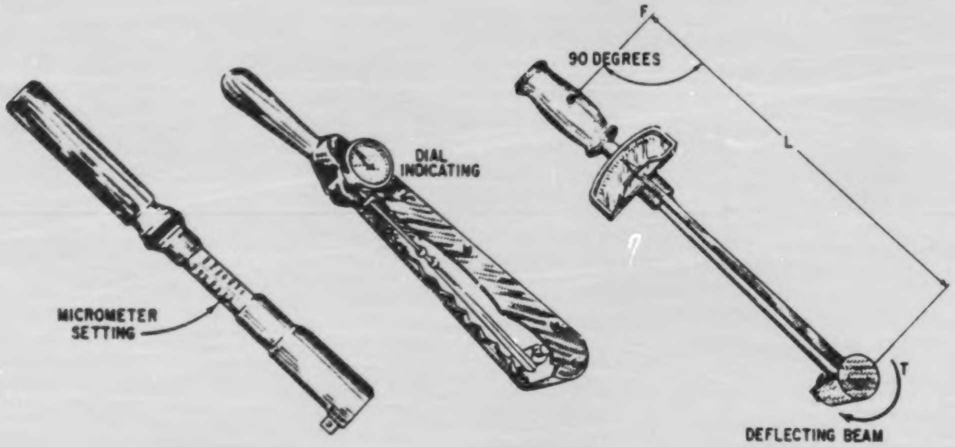
Accessories

To complete the socket wrench set, there are several accessory items. Extension bars of different lengths are made to extend the distance from the socket to the handle. A universal joint allows the nut to be turned with the wrench handle at an angle. Universal sockets are also available. The use of universal joints, bar extensions, and universal sockets in combination with appropriate handles makes it possible to form a variety of tools that will reach otherwise inaccessible nuts and bolts.

Another accessory item is an adapter which allows you to use a handle having one size of drive and a socket having a different size drive. For example, a 3/8- by 1/4-inch adapter makes it possible to turn all 1/4-inch square drive sockets with any 3/8-inch-square drive handle.

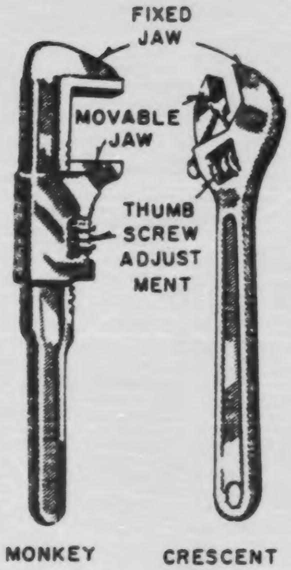
TORQUE WRENCHES

There are times when, for engineering reasons, a definite force must be applied to a nut or bolt head. In such cases a torque wrench must be used. For example, equal force must be applied to all the head bolts of an engine. Otherwise, one bolt may bear the brunt of the force of internal combustion and ultimately cause engine failure.



5.9

Figure 1-12.—Torque wrenches.



44.6(44)B

Figure 1-13.—Adjustable wrenches.

The three most commonly used torque wrenches are the Deflecting Beam, Dial Indicating, and Micrometer Setting types (fig. 1-12). When using the Deflecting Beam and the Dial Indicating torque wrenches, the torque is read visually on a dial or scale mounted on the handle of the wrench.

To use the Micrometer Setting type, unlock the grip and adjust the handle to the desired setting on the micrometer type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion. (A fast or jerky motion will result in an improperly torqued unit.) When the torque applied reaches the torque value, which is indicated on the handle setting, a signal mechanism will automatically issue an audible click, and the handle will release or "break," and move freely for a short distance. The release and free travel is easily felt, so there is no doubt about when the torquing process is complete.

Manufacturers' and technical manuals generally specify the amount of torque to be applied. To assure getting the correct amount of torque on the fasteners, it is important that the wrench be used properly in accordance with manufacturers' instructions.

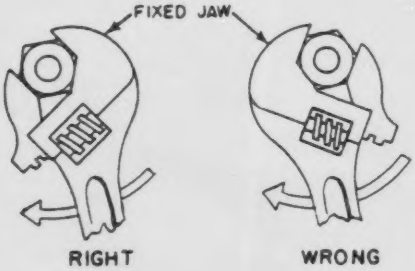
Use that torque wrench which will read about mid-range for the amount of torque to be applied. BE SURE THAT THE TORQUE WRENCH HAS BEEN CALIBRATED BEFORE YOU USE IT. Remember, too, that the accuracy of torque-measuring depends a lot on how the threads are cut and the cleanliness of the threads. Make sure you inspect and clean the threads. If the manufacturer specifies a thread lubricant, it must be used to obtain the most accurate torque reading. When using the Deflecting Beam or Dial Indicating wrenches, hold the torque at the desired value until the reading is steady.

Torque wrenches are delicate and expensive tools. The following precautions should be observed when using them:

1. When using the Micrometer Setting type, do not move the setting handle below the lowest torque setting. However, it should be placed at its lowest setting prior to returning to storage.
2. Do not use the torque wrench to apply greater amounts of torque than its rated capacity.
3. Do not use the torque wrench to break loose bolts which have been previously tightened.
4. Do not drop the wrench. If dropped, the accuracy will be affected.
5. Do not apply a torque wrench to a nut that has been tightened. Back off the nut one turn with a non-torque wrench and retighten to the correct torque with the indicating torque wrench.
6. Calibration intervals have been established for all torque tools used in the Navy. When a tool is calibrated by a qualified calibration activity at a shipyard, tender, or repair ship, a label showing the next calibration due date is attached to the handle. This date should be checked before a torque tool is used to ensure that it is not overdue for calibration.

ADJUSTABLE WRENCHES

A handy all-round wrench that is generally included in every toolbox is the adjustable open-end wrench. This wrench is not intended to take the place of the regular solid open-end wrench. Additionally, it is not built for use on extremely hard-to-turn items. Its usefulness is achieved by being capable of fitting odd-sized nuts. This flexibility is achieved although one jaw of the adjustable open-end wrench is fixed because the other jaw is moved along a slide by a thumbscrew adjustment (fig. 1-13). By turning the thumbscrew, the jaw opening may be adjusted to fit various sizes of nuts.



1.16.6(1)

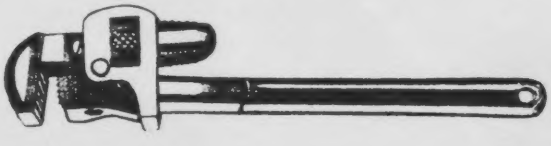
Figure 1-14.—Proper procedure for pulling adjustable wrenches.

Adjustable wrenches are available in varying sizes ranging from 4 to 24 inches in length. The size of the wrench selected for a particular job is dependent upon the size of nut or bolt head to which the wrench is to be applied. As the jaw opening increases the length of the wrench increases.

Adjustable wrenches are often called "knuckle busters," because mechanics frequently suffer these consequences as a result of improper usage of these tools. To avoid accidents, follow four simple steps. First, choose a wrench of the correct size; that is, do not pick a large 12-inch wrench and adjust the jaw for use on a 3/8-inch nut. This could result in a broken bolt and a bloody hand. Second, be sure the jaws of the correct size wrench are adjusted to fit snugly on the nut. Third, position the wrench around the nut until the nut is all the way into the throat of the jaws. If not used in this manner, the result is apt to be as bloody as before. Fourth, pull the handle toward the side having the adjustable jaw (fig. 1-14). This will prevent the adjustable jaw from springing open and slipping off the nut. If the location of the work will not allow for all four steps to be followed when using an adjustable wrench, then select another type of wrench for the job.

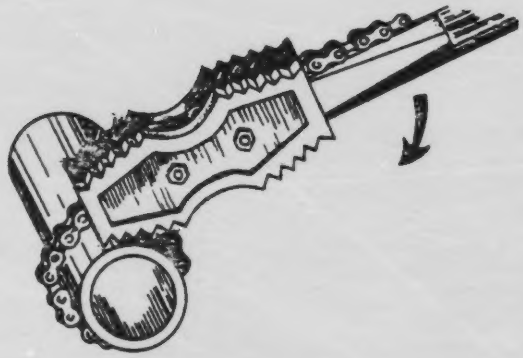
Pipe Wrench (Stillson)

When rotating or holding round work an adjustable pipe wrench (Stillson) may be used (fig. 1-15). The movable jaw on a pipe wrench is



44.6

Figure 1-15.—Adjustable pipe wrench.



44.7

Figure 1-16.—Chain pipe wrench.

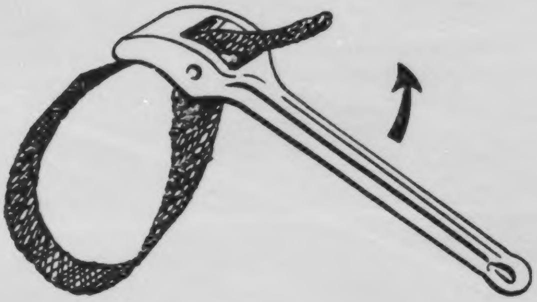


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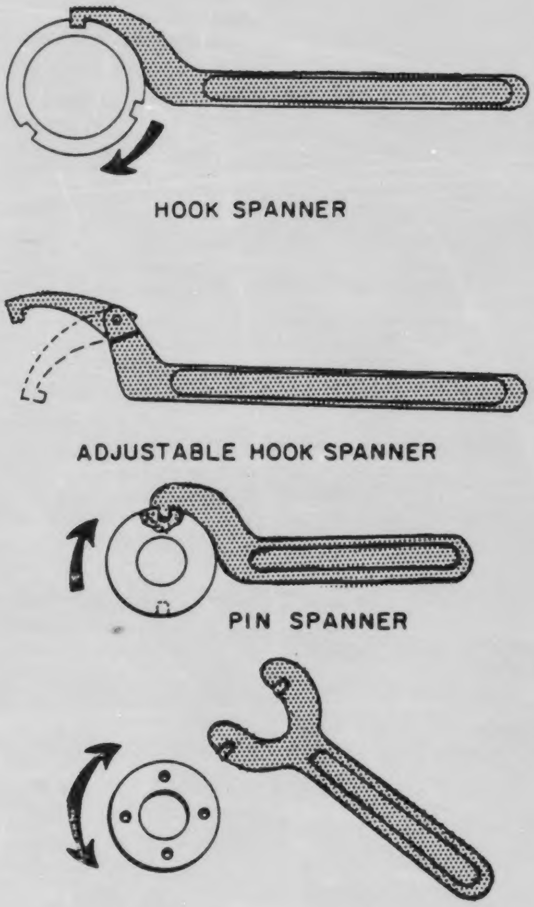
Figure 1-17.—Strap wrench.



1.17:44.8

Figure 1-18.—General-purpose spanner wrenches.

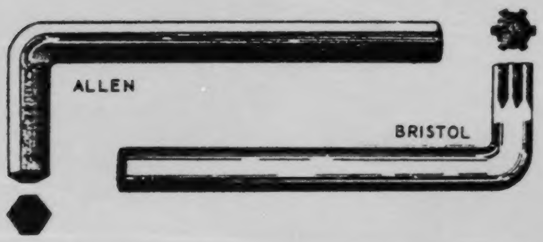
pivoted to permit a gripping action on the work. This tool must be used with discretion, as the jaws are serrated and always make marks on the work unless adequate precautions are observed. The jaws should be adjusted so the bite on the work will be taken at about the center of the jaws.

Chain Pipe Wrench

A different type pipe wrench, used mostly on large sizes of pipe, is the chain/pipe wrench (fig. 1-16). This tool works in one direction only, but can be backed partly around the work and a fresh hold taken without freeing the chain. To reverse the operation the grip is taken on the opposite side of the head. The head is double ended and can be reversed when the teeth on one end are worn out.

Strap Wrench

The strap wrench (fig. 1-17) is similar to the chain pipe wrench but uses a heavy web strap in place of the chain. This wrench is used for turning pipe or cylinders where you do not want to mar the surface of the work. To use this wrench, the webbed strap is placed



1.17.1-.2
Figure 1-19.—Allen and Bristol type wrenches.

around the cylinder and passed through the slot in the metal body of the wrench. The strap is then pulled up tight and as the mechanic turns the wrench in the desired direction, the webbed strap tightens further around the cylinder. This gripping action causes the cylinder to turn.

SPANNER WRENCHES

Many special nuts are made with notches cut into their outer edge. For these nuts a hook spanner (fig. 1-18) is required. This wrench has a curved arm with a lug or hook on the end. This lug fits into one of the notches of the nut and the handle turned to loosen or tighten the nut. This spanner may be made for just one particular size of notched nut, or it may have a hinged arm to adjust it to a range of sizes.

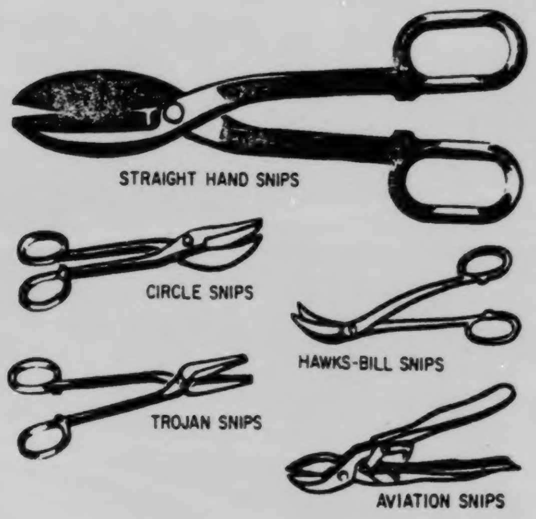
Another type of spanner is the pin spanner. Pin spannershave a pin in place of a hook. This pin fits into a hole in the outer part of the nut.

Face pin spanners are designed so that the pins fit into holes in the face of the nut (fig. 1-18).

When you use a spanner wrench, you must ensure that the pins, lugs, or hooks make firm contact with the nut while the turning force is transferred from the wrench to the nut. If this is not done, damage will result to either personnel, tools, or equipment.

SETSCREW WRENCHES (ALLEN AND BRISTOL)

In some places it is desirable to use recessed heads on setscrews and capscrews. One type (Allen) screw is used extensively on office machines and in machine shops. The other type (Bristol) is used infrequently.



44.10
Figure 1-20.—Snips.

Recessed head screws usually have a hex-shaped (six-sided) recess. To remove or tighten this type screw requires a special wrench that will fit in the recess. This wrench is called an Allen-type wrench. Allen-type wrenches are made from hexagonal L-shaped bars of tool steel (fig. 1-19). They range in size up to 3/4 inch. When using the Allen-type wrench make sure you use the correct size to prevent rounding or spreading the head of the screw. A snug fit within the recessed head of the screw is an indication that you have the correct size.

The Bristol wrench is made from round stock. It is also L-shaped, but one end is fluted to fit the flutes or little splines in the Bristol setscrew (fig. 1-19).

NONSPARKING WRENCHES

Nonsparking wrenches are wrenches that will not cause sparks to be generated when working with steel nuts and bolts. They are generally made from a copper alloy (bronze). However, they may be made from other nonsparking materials.

Nonsparkingwrenches must be used in areas where flammable materials are present. These tools are used extensively when working around gasoline-carrying vehicles and when working around aircraft or explosives.

SAFETY RULES FOR WRENCHES

There are a few basic rules that you should keep in mind when using wrenches. They are:

1. Always use a wrench that fits the nut properly.
2. Keep wrenches clean and free from oil. Otherwise they may slip, resulting in possible serious injury to you or damage to the work.
3. Do not increase the leverage of a wrench by placing a pipe over the handle. Increased leverage may damage the wrench or the work.
4. Provide some sort of kit or case for all wrenches. Return them to it at the completion of each job. This saves time and trouble and facilitates selection of tools for the next job. Most important, it eliminates the possibility of leaving them where they can cause injury or damage to men or equipment.
5. Determine which way a nut should be turned before trying to loosen it. Most nuts are turned counterclockwise for removal. This may seem obvious, but even experienced men have been observed straining at the wrench in the tightening direction when they wanted to loosen it.
6. Learn to select your wrenches to fit the type of work you are doing. If you are not familiar with these wrenches, make arrangements to visit a shop that has most of them and get acquainted.

METAL CUTTING TOOLS

There are many types of metal cutting tools used by skilled mechanics of all ratings. As you become better acquainted with your rating, you will probably discover many tools that you use for cutting metal that are not described in this text. In this text, only the basic hand metal cutting tools will be considered.

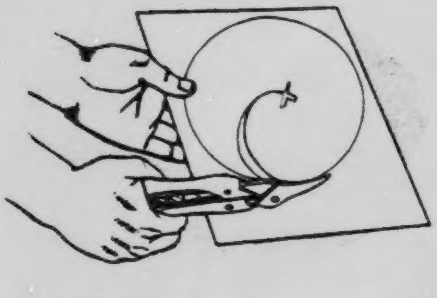
SNIPS AND SHEARS

Snips and shears are used for cutting sheet metal and steel of various thicknesses and shapes. Normally, the heavier or thicker materials are cut by shears.

One of the handiest tools for cutting light (up to 1/16 inch thick) sheet metal is the hand snip (tip snips). The STRAIGHT HAND SNIPS shown in fig. 1-20 have blades that are straight and cutting edges that are sharpened to an 85-degree angle. Snips like this can be obtained in different sizes ranging from the small 6-inch to the large 14-inch snip. Tin snips will also work on slightly heavier gages of soft metals such as aluminum alloys.

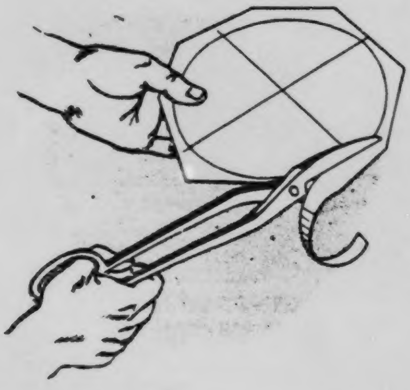
Snips will not remove any metal when a cut is made. There is danger, though, of causing minute metal fractures along the edges of the metal during the shearing process. For this reason, it is better to cut just outside the layout line. This procedure will allow you to dress the cutting edge while keeping the material within required dimensions.

Cutting extremely heavy gage metal always presents the possibility of springing the blades. Once the blades are sprung, hand snips are useless. When cutting heavy material use the rear portion of the blades. This procedure not only



11.253X

Figure 1-21.—Cutting an inside hole with snips.



11.252X

Figure 1-22.—Cutting a disk out of sheet metal.

avoids the possibility of springing the blades but also gives you greater cutting leverage.

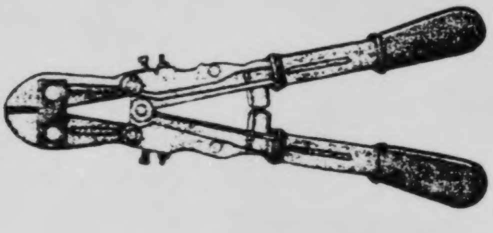
Many snips have small serrations (notches) on the cutting edges of the blades. These serrations tend to prevent the snips from slipping backwards when a cut is being made. Although this feature does make the actual cutting easier, it mars the edges of the metal slightly. You can remove these small cutting marks if you allow proper clearance for dressing the metal to size. There are many other types of hand snips used for special jobs but the snips discussed here can be used for almost any common type of work.

Cutting Sheet Metal with Snips

It is hard to cut circles or small arcs with straight snips. There are snips especially designed for circular cutting. They are called CIRCLE SNIPS, HAWKS-BILL SNIPS, TROJAN SNIPS, and AVIATION SNIPS (fig. 1-20).

To cut large holes in the lighter gages of sheet metal, start the cut by punching or otherwise making a hole in the center of the area to be cut out. With an aviation snips, as shown in figure 1-21, or some other narrow-bladed snips, make a spiral cut from the starting hole out toward the scribed circle and continue cutting until the scrap falls away.

To cut a disk in the lighter gages of sheet metal, use a combination snips or a straight blade snips as shown in figure 1-22. First, cut away any surplus material outside of the scribed circle leaving only a narrow piece to be removed by the final cut. Make the final cut just outside of the layout line. This will permit you to see the scribed line while you are cutting and will cause the scrap to curl up below the blade of the snips where it will be out of the way while the complete cut is being made.



44.12

Figure 1-23.—Bolt cutters.

To make straight cuts, place the sheet metal on a bench with the marked guideline over the edge of the bench and hold the sheet down with one hand. With the other hand hold the snips so that the flat sides of the blades are at right angles to the surface of the work. If the blades are not at right angles to the surface of the work, the edges of the cut will be slightly bent and burred. The bench edge will also act as a guide when cutting with the snips. The snips will force the scrap metal down so that it does not interfere with cutting. Any of the hand snips may be used for straight cuts. When notches are too narrow to be cut out with a pair of snips, make the side cuts with the snips and cut the base of the notch with a cold chisel.

Safety and Care

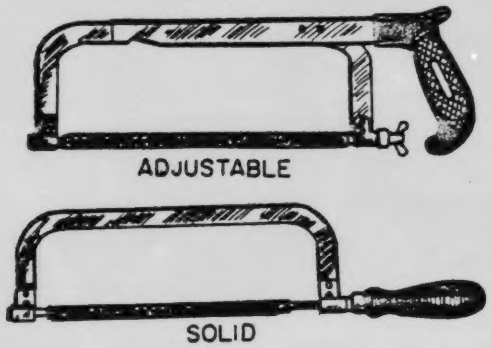
Learn to use snips properly. They should always be oiled and adjusted to permit ease of cutting and to produce a surface that is free from burrs. If the blades bind, or if they are too far apart, the snips should be adjusted.

Never use snips as screwdrivers, hammers, or pry bars. They break easily.

Do not attempt to cut heavier materials than the snips are designed for. Never use tin snips to cut hardened steel wire or other similar objects. Such use will dent or nick the cutting edges of the blades.

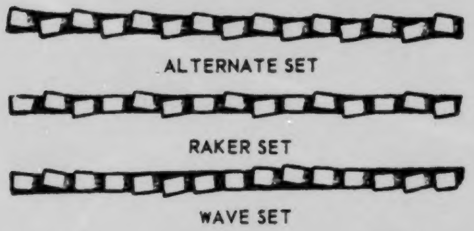
Never toss snips in a toolbox where the cutting edges can come into contact with other tools. This dulls the cutting edges and may even break the blades.

When snips are not in use, hang them on hooks or lay them on an uncrowded shelf or bench.

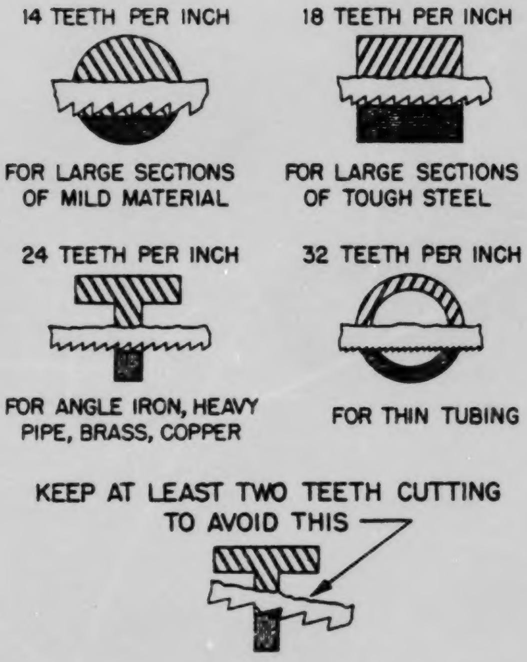


1.19(44)

Figure 1-24.—Hacksaws.


ALTERNATE SET
RAKER SET
WAVE SET

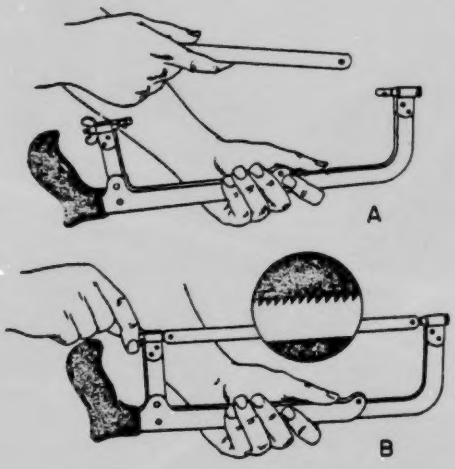
28.40(44)
Figure 1-25.—"Set" of hacksaw blade teeth.


14 TEETH PER INCH
18 TEETH PER INCH
FOR LARGE SECTIONS OF MILD MATERIAL
FOR LARGE SECTIONS OF TOUGH STEEL
24 TEETH PER INCH
32 TEETH PER INCH
FOR ANGLE IRON, HEAVY PIPE, BRASS, COPPER
FOR THIN TUBING
KEEP AT LEAST TWO TEETH CUTTING TO AVOID THIS

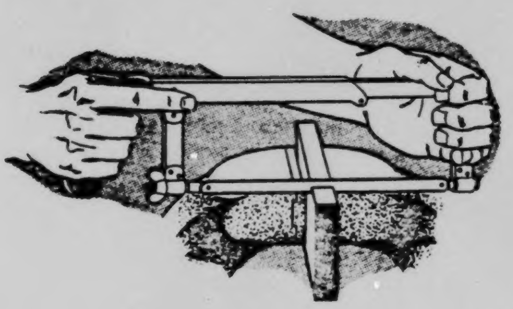
44.167
Figure 1-26.—Selecting the proper hacksaw blade.

BOLT CUTTERS

Bolt cutters (fig. 1-23) are giant shears with very short blades and long handles. The handles are hinged at one end. The cutters are at the ends of extensions which are jointed in such a way that the inside joint is forced outwards when the handles are closed, thus forcing the cutting edges together with great force.



44.168
Figure 1-27.—Installing a hacksaw blade.



11.4
Figure 1-28.—Proper way to hold a hacksaw.

Bolt cutters are made in lengths of 18 to 36 inches. The larger ones will cut mild steel bolts and rods up to 1/2 inch. The material to be cut should be kept as far back in the jaws as possible. Never attempt to cut spring wire or other tempered metal with bolt cutters. This will cause the jaws to be sprung or nicked.

Adjusting screws near the middle hinges provide a means for ensuring that both jaws move the same amount when the handles are pressed together. Keep the adjusting screws just tight enough to ensure that the cutting edges meet along their entire length when the jaws are closed. The hinges should be kept well oiled at all times.

632

When using bolt cutters make sure your fingers are clear of the jaws and hinges. Take care that the bolt head or piece of rod cut off does not fly and injure you or someone else. If the cutters are brought together rapidly, sometimes a bolt-head or piece of rod being cut off will fly some distance.

Bolt cutters are fairly heavy, so make sure that they are stored in a safe place where they will not fall and injure someone.

HACKSAWS

Hacksaws are used to cut metal that is too heavy for snips or boltcutters. Thus, metal bar stock can be cut readily with hacksaws.

There are two parts to a hacksaw; the frame and the blade. Common hacksaws have either an adjustable or solid frame (fig. 1-24). Most hacksaws found in the Navy are of the adjustable frame type. Adjustable frames can be made to hold blades from 8 to 16 inches long, while those with solid frames take only the length blade for which they are made. This length is the distance between the two pins that hold the blade in place.

Hacksaw blades are made of high-grade tool steel, hardened and tempered. There are two types, the all-hard and the flexible. All hard blades are hardened throughout, whereas only the teeth of the flexible blades are hardened. Hacksaw blades are about one-half inch wide, have from 14 to 32 teeth per inch, and are from 8 to 16 inches long. The blades have a hole at each end which hooks to a pin in the frame. All hacksaw frames which hold the blades either parallel or at right angles to the frame are provided with a wingnut or screw to permit tightening or removing the blade.

The SET in a saw refers to how much the teeth are pushed out in opposite directions from the sides of the blade. The four different kinds of set are ALTERNATE set, DOUBLE ALTERNATE set, RAKER set, and WAVE set. Three of these are shown in figure 1-25.

The teeth in the alternate set are staggered, one to the left and one to the right throughout the length of the blade. On the double alternate set blade, two adjoining teeth are staggered to the right, two to the left, and so on. On the raker set blade, every third tooth remains straight and the other two are set alternately. On the wave (undulated) set blade, short sections of teeth are bent in opposite directions.

Using Hacksaws

The hacksaw is often used improperly. Although it can be used with limited success by an inexperienced man, a little thought and study given to its proper use will result in faster and better work and less dulling and breaking of blades.

Good work with a hacksaw depends not only upon the proper use of the saw, but also upon the proper selection of the blades for the work to be done. Figure 1-26 will help you select the proper blade to use when sawing metal with a hacksaw. Coarse blades with fewer teeth per inch cut faster and are less liable to choke up with chips. However, finer blades with more teeth per inch are necessary when thin sections are being cut. The selection should be made so that, as each tooth starts its cut, the tooth ahead of it will still be cutting.

To make the cut, first install the blade in the hacksaw frame (fig. 1-27) so that the teeth point away from the handle of the hacksaw. (Hand hacksaws cut on the push stroke.) Tighten the wingnut so that the blade is definitely under tension. This helps make straight cuts.

Place the material to be cut in a vise. A minimum of overhang will reduce vibration, give a better cut, and lengthen the life of the blade. Have the layout line outside of the vise jaw so that the line is visible while you work.

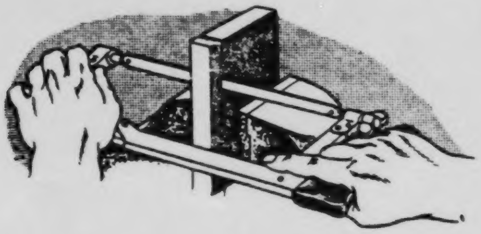
The proper method of holding the hacksaw is depicted in figure 1-28. See how the index finger of the right hand, pointed forward, aids in guiding the frame.

When cutting, let your body sway ahead and back with each stroke. Apply pressure on the forward stroke, which is the cutting stroke, but not on the return stroke. From 40 to 50 strokes per minute is the usual speed. Long, slow, steady strokes are preferred.

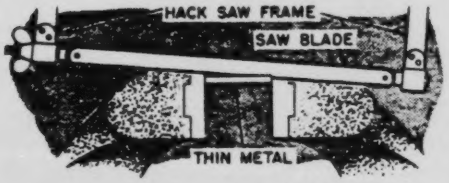
For long cuts (fig. 1-29) rotate the blade in the frame so that the length of the cut is not limited by the depth of the frame. Hold the work with the layout line close to the vise jaws, raising the work in the vise as the sawing proceeds.

Saw thin metal as shown in figure 1-30. Notice the long angle at which the blade enters the saw groove (kerf). This permits several teeth to be cutting at the same time.

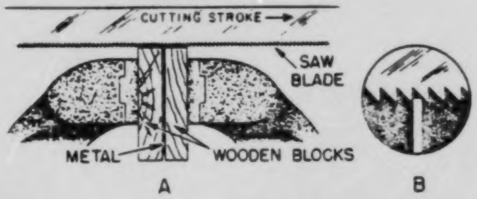
Metal which is too thin to be held, as shown in figure 1-30, can be placed between blocks of wood, as shown in figure 1-31. The wood provides support for several teeth as they are



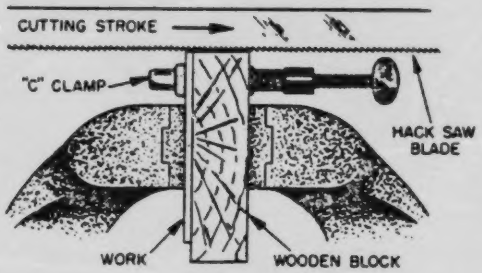
44.169
Figure 1-29.—Making a long cut near the edge of stock.



44.170
Figure 1-30.—Cutting thin metal with a hacksaw.



44.171
Figure 1-31.—Cutting thin metal between two wooden blocks.



44.172
Figure 1-32.—Cutting thin metal using wood block with layout lines.

cutting. Without the wood, as shown at B in figure 1-31, teeth will be broken due to excessive vibration of the stock and because individual teeth have to absorb the full power of the stroke.

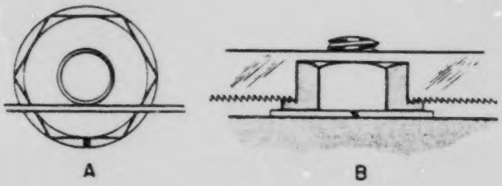
Cut thin metal with layout lines on the face by using a piece of wood behind it (fig. 1-32). Hold the wood and the metal in the jaws of the vise, using a C-clamp when necessary. The wood block helps support the blade and produces a smoother cut. Using the wood only in back of the metal permits the layout lines to be seen.

To remove a frozen nut with a hacksaw, saw into the nut as shown in figure 1-33, starting the blade close to the threads on the bolt or stud and parallel to one face of the nut as shown in figure 1-33A. Saw parallel to the bolt until the teeth of the blade almost reach the lockwasher. Lockwashers are hard and will ruin hacksaw blades, so do not try to saw them. Figure 1-33B shows when to stop sawing. Then, with a cold chisel and hammer, remove this one side of the nut completely by opening the saw kerf. Put an adjustable wrench across this new flat and the one opposite, and again try to remove the frozen nut. Since very little original metal remains on this one side of the nut, the nut will either give or break away entirely and permit its removal.

To saw a wide kerf in the head of a cap screw or machine bolt, fit the hand hacksaw frame with two blades side by side, and with teeth lined up in the same direction. With slow, steady strokes, saw the slot approximately one-third the thickness of the head of the cap screw as shown in figure 1-34. Such a slot will permit subsequent holding or turning with a screwdriver when it is impossible, due to close quarters, to use a wrench.

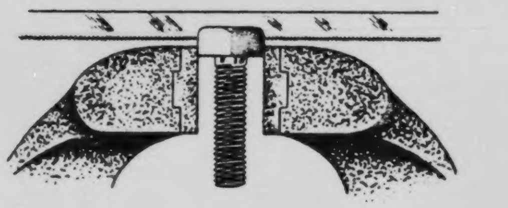
Hacksaw Safety

The main danger in using hacksaws is injury to your hand if the blade breaks. The blade will break if too much pressure is applied, when the saw is twisted, when the cutting speed is too fast, or when the blade becomes loose in the frame. Additionally, if the work is not tight in the vise, it will sometimes slip, twisting the blade enough to break it.



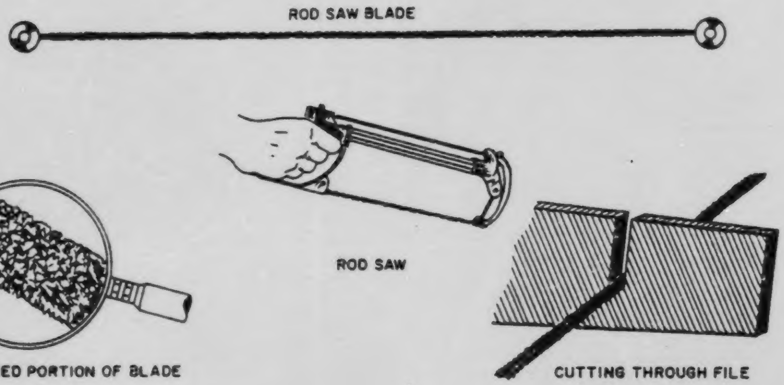
44.174

Figure 1-33.—Removing a frozen nut with a hacksaw.



44.173

Figure 1-34.—Cutting a wide kerf in the head of a capscrew or bolt.



29.15(44B)X

Figure 1-35.—Rod Saw and operations.

ROD SAWS

An improvement in industrial technology provides us with a tool that can cut material an ordinary hacksaw can't even scratch. The rod saw (fig. 1-35) acts like a diamond in its capability of cutting hard metals and materials such as stainless steel, Inconel, titanium, and carbon phenolics.

The rod saw cuts through material by means of hundreds of tungsten-carbide particles permanently bonded to the rod (see magnified portion of fig. 1-35). The rod saw cuts through stainless steel and files with ease.

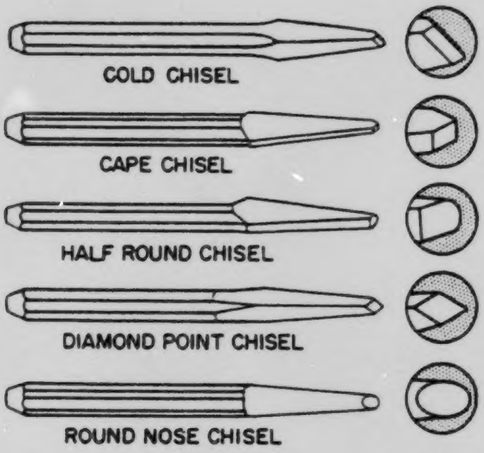
A unique feature of this saw is its capability of cutting on the forward and reverse strokes.

CHISELS

Chisels are tools that can be used for chipping or cutting metal. They will cut any metal that is softer than the materials of which they are made. Chisels are made from a good grade tool steel and have a hardened cutting edge and beveled head. Cold chisels are classified according to the shape of their points, and the width of the cutting edge denotes their size. The most common shapes of chisels are flat (cold chisel), cape, round nose, and diamond point (fig. 1-36).

The type chisel most commonly used is the flat cold chisel, which serves to cut rivets, split nuts, chip castings, and cut thin metal sheets. The cape chisel is used for special jobs like cutting keyways, narrow grooves and square corners. Round-nose chisels make circular grooves and chip inside corners with a fillet. Finally, the diamond-point is used for cutting V-grooves and sharp corners.

As with other tools there is a correct technique for using a chisel. Select a chisel that is large enough for the job. Be sure to use a hammer that matches the chisel; that is, the larger the chisel, the heavier the hammer. A heavy


COLD CHISEL
CAPE CHISEL
HALF ROUND CHISEL
DIAMOND POINT CHISEL
ROUND NOSE CHISEL

29.9M
Figure 1-36.—Types of points on metal cutting chisel.

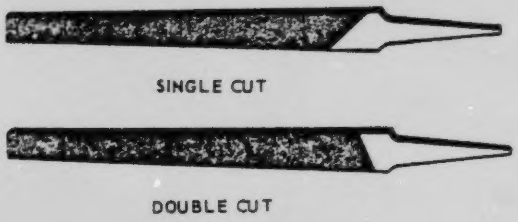
chisel will absorb the blows of a light hammer and will do virtually no cutting.

As a general rule, hold the chisel in the left hand with the thumb and first finger about 1 inch from the top. It should be held steadily but not tightly. The finger muscles should be relaxed, so if the hammer strikes the hand it will permit the hand to slide down the tool and lessen the effect of the blow. Keep the eyes on the cutting edge of the chisel, not on the head, and swing the hammer in the same plane as the body of the chisel. If you have a lot of chiseling to do, slide a piece of rubber hose over the chisel. This will lessen the shock to your hand.

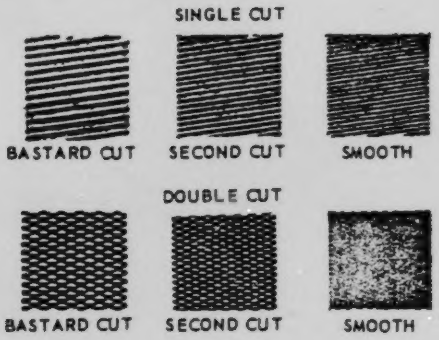
When using a chisel for chipping, always wear goggles to protect your eyes. If other men are working close by, see that they are protected from flying chips by erecting a screen or shield to contain the chips. Remember that the time to take these precautions is before you start the job.

FILES

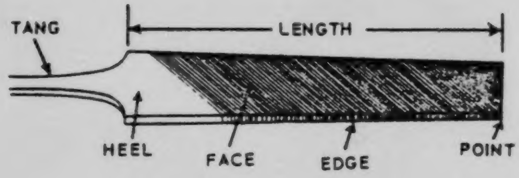
A toolkit for nearly every rating in the Navy is not complete unless it contains an assortment of files. There are a number of different types of files in common use, and each type may range in length from 3 to 18 inches.


SINGLE CUT
DOUBLE CUT

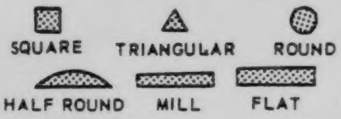
A. SINGLE AND DOUBLE-CUT FILES


SINGLE CUT
BASTARD CUT
SECOND CUT
SMOOTH
DOUBLE CUT
BASTARD CUT
SECOND CUT
SMOOTH

B. DESIGN AND SPACING OF FILE TEETH


TANG
LENGTH
HEEL
FACE
EDGE
POINT

C. FILE NOMENCLATURE.


SQUARE
TRIANGULAR
ROUND
HALF ROUND
MILL
FLAT

D. CROSS-SECTIONAL SHAPES OF FILES

1.20(44B)A
Figure 1-37.—File information.

Grades

Files are graded according to the degree of fineness, and according to whether they have single- or double-cut teeth. The difference is apparent when you compare the files in figure 1-37A.

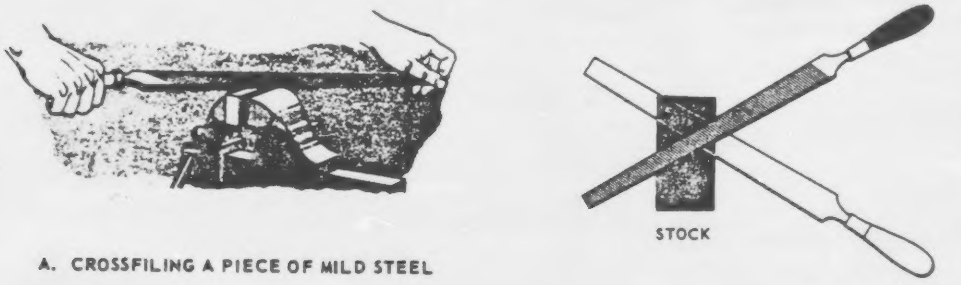
Single-cut files have rows of teeth cut parallel to each other. These teeth are set at an angle of about 65 degrees with the centerline. You will use single-cut files for sharpening tools, finish filing, and drawfiling. They are also the best tools for smoothing the edges of sheet metal.

Files with crisscrossed rows of teeth are double-cut files. The double cut forms teeth that are diamond-shaped and fast cutting. You will use double-cut files for quick removal of metal, and for rough work.

Files are also graded according to the spacing and size of their teeth, or their coarseness and fineness. Some of these grades are pictures in fig. 1-37B. In addition to the three grades shown, you may use some DEAD SMOOTH files, which have very fine teeth, and some ROUGH files with very coarse teeth. The fineness or coarseness of file teeth is also influenced by the length of the file. (The length of a file is the distance from the tip to the heel, and does not include the tang (fig. 1-37C).) When you have a chance, compare the actual size of the teeth of a 6-inch, single-cut smooth file and a 12-inch, single-cut smooth file; you will notice the 6-inch file has more teeth per inch than the 12-inch file.

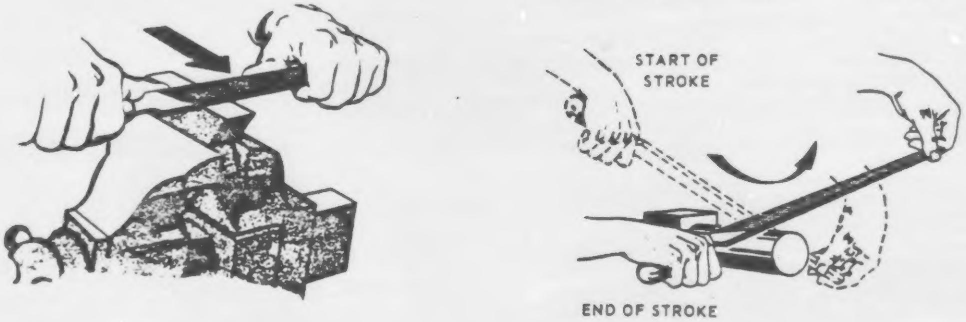
Shapes

Files come in different shapes. Therefore, in selecting a file for a job, the shape of the finished work must be considered. Some of the cross sectional shapes are shown in figure 1-37D.



A. CROSSFILING A PIECE OF MILD STEEL

B. ALTERNATING POSITIONS WHEN FILING



C. DRAWFILING A SMALL PART

D. FILING ROUND METAL STOCK

1.20(44B)B

Figure 1-38.—Filing operations.

TRIANGULAR files are tapered (longitudinally) on all three sides. They are used to file acute internal angles, and to clear out square corners. Special triangular files are used to file saw teeth.

MILL files are tapered in both width and thickness. One edge has no teeth and is known as a SAFE EDGE. Mill files are used for smoothing lathe work, drawfiling, and other fine, precision work. Mill files are always single-cut.

FLAT files are general-purpose files and may be either single- or double-cut. They are tapered in width and thickness. HARD files, not shown, are somewhat thicker than flat files. They taper slightly in thickness, but their edges are parallel.

The flat or hard files most often used are the double-cut for rough work and the single-cut, smooth file for finish work.

SQUARE files are tapered on all four sides and are used to enlarge rectangular-shaped holes and slots. ROUND files serve the same purpose for round openings. Small round files are often called "rattail" files.

The HALF ROUND file is a general-purpose tool. The rounded side is used for curved surfaces and the flat face on flat surfaces. When you file an inside curve, use a round or half-round file whose curve most nearly matches the curve of the work.

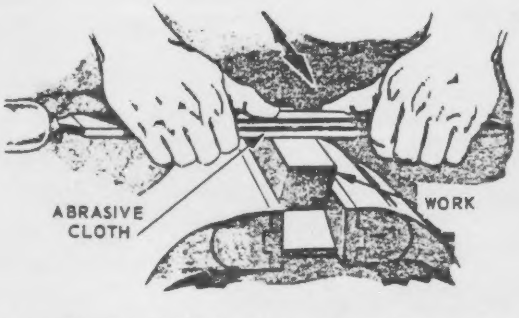
Kits of small files, often called "Swiss Pattern" or "Jewelers" files, are used to fit parts of delicate mechanisms, and for filing work on instruments. Handle these small files carefully because they break easily.

FILING OPERATIONS

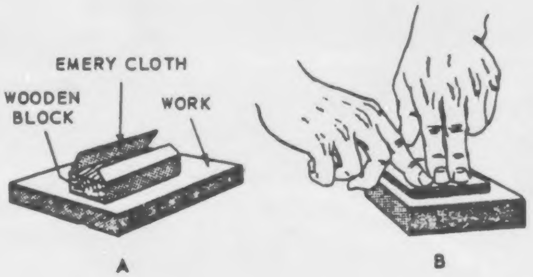
Using a file is an operation that is nearly indispensable when working with metal. You may be crossfiling, drawfiling, using a file card, or even polishing metal. Let's examine these operations.

When you have finished using a file it may be necessary to use an abrasive cloth or paper to finish the product. Whether this is necessary depends on how fine a finish you want on the work.

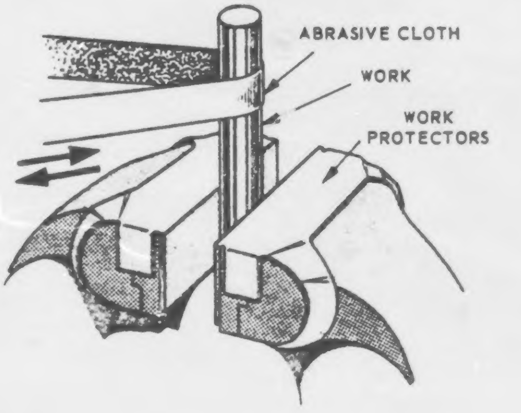
CROSSFILING.—Figure 1-38A shows a piece of mild steel being crossfiled. This means that the file is being moved across the surface of the work in approximately a crosswise direction.



A. POLISHING METAL WITH ABRASIVE CLOTH WRAPPED AROUND A FILE



B. ALTERNATE METHODS FOR POLISHING METAL SURFACE



C. POLISHING ROUND METAL STOCK

44.135:.136

Figure 1-39.—Polishing operations.

For best results, keep your feet spread apart to steady yourself as you file with slow, full-length, steady strokes. The file cuts as you push it—ease up on the return stroke to keep from dulling the teeth. Keep your file clean.

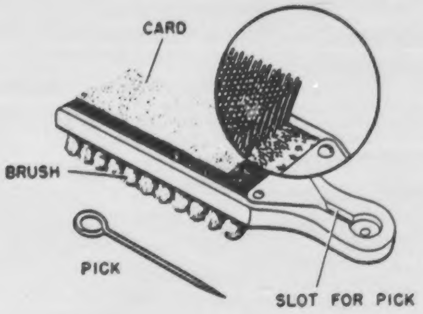
Figure 1-38B shows the alternate positions of the file when an exceptionally flat surface is required. Using either position first, file across the entire length of the stock. Then, using the other position, file across the entire length of the stock again. Because the teeth of the file pass over the surface of the stock from two directions, the high spots and low spots will readily be visible after filing in both positions. Continue filing first in one position or direction and then the other until the surface has been filed flat. Test the flatness with a straight edge or with prussian blue and a surface plate.

DRAW FILING.—Draw filing produces a finer surface finish and usually a flatter surface than crossfiling. Small parts, as shown in figure 1-38C, are best held in a vise. Hold the file as shown in the figure; notice that the arrow indicates that the cutting stroke is away from you when the handle of the file is held in the right hand. If the handle is held in the left hand, the cutting stroke will be toward you. Lift the file away from the surface of the work on the return stroke. When draw filing will no longer improve the surface texture, wrap a piece of abrasive cltoh around the file and polish the surface as shown in figure 1-39A.

USE OF FILE CARD.—As you file, the teeth of the file may "clog up" with some of the metal filings and scratch your work. This condition is known as PINNING. You can prevent pinning by keeping the file teeth clean. Rubbing chalk between the teeth will help prevent pinning, too, but the best method is to clean the file frequently with a FILE CARD or brush. A file card (fig. 1-40) has fine wire bristles. Brush with a pulling motion, holding the card parallel to the rows of teeth.

Always keep the file clean, whether you're filing mild steel or other metals. Use chalk liberally when filing nonferrous metals.

FILING ROUND METAL STOCK.—Figure 1-38D shows that, as a file is passed over the surface of round work, its angle with the work is changed. This results in a rocking motion of the file as it passes over the work. This rocking motion permits all the teeth on the file to make contact and cut as they pass over the work's surface, thus tending to keep the file much cleaner and thereby doing better work.



44.11

Figure 1-40.—File cleaner.

POLISHING A FLAT METAL SURFACE.—When polishing a flat metal surface, first draw file the surface as shown in fig. 1-38C. Then, when the best possible draw filed surface has been obtained, proceed with abrasive cloth, often called emery cloth. Select a grade of cloth suited to the draw filing. If the draw filing was well done only a fine cloth will be needed to do the polishing.

If your cloth is in a roll, and the job you are polishing is the size that would be held in a vise, tear off a 6" or 8" length of the 1" or 2" width. If you are using sheets of abrasive cloth, tear off a strip from the long edge of the 8" by 11" sheet.

Wrap the cloth around the file (fig. 1-39A) and hold the file as you would for draw filing. Hold the end of the cloth in place with your thumb. In polishing, apply a thin film of lubricating oil on the surface being polished and use a double stroke with pressure on both the forward and the backward strokes. Note that this is different from the drawfiling stroke in which you cut with the file in only one direction.

When further polishing does not appear to improve the surface, you are ready to use the next finer grade of cloth. Before changing to the finer grade, however, reverse the cloth so that its back is toward the surface being polished.

Work the reversed cloth back and forth in the abrasive-laden oil as an intermediate step between grades of abrasive cltoh. Then, with the solvent available in your shop, clean the job thoroughly before proceeding with the next finer grade of cloth. Careful cleaning between grades helps to ensure freedom from scratches.

For the final polish, use a strip of crocus cloth—first the face and then the back—with plenty of oil. When polishing is complete, again carefully clean the job with a solvent and protect it, with oil or other means, from rusting.

Figure 1-39B(A) shows another way to polish in which the abrasive cloth is wrapped around a block of wood. In figure 1-39B(B), the cloth has simply been folded to form a pad from which a worn, dull surface can be removed by simply tearing it off to expose a new surface.

POLISHING ROUND METAL STOCK.—In figure 1-39C, a piece of round stock is being polished with a strip of abrasive cloth which is "seesawed" back and forth as it is guided over the surface being polished.

Remember that the selection of grades of abrasive cloth, the application of oil, and the cleaning between grades, applies to polishing regardless of how the cloth is held or used.

Care of Files

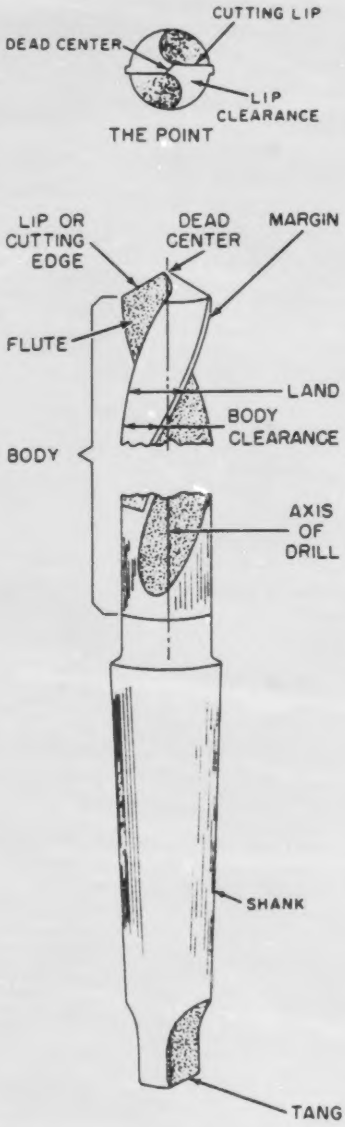
A new file should be broken in carefully by using it first on brass, bronze, or smooth cast iron. Just a few of the teeth will cut at first, so use a light pressure to prevent tooth breakage. Do not break in a new file by using it first on a narrow surface.

Protect the file teeth by hanging your files in a rack when they are not in use, or by placing them in drawers with wooden partitions. Your files should not be allowed to rust—keep them away from water and moisture. Avoid getting the files oily. Oil causes a file to slide across the work and prevents fast, clean cutting. Files that you keep in your toolbox should be wrapped in paper or cloth to protect their teeth and prevent damage to other tools.

Never use a file for prying or pounding. The tang is soft and bends easily. The body is hard and extremely brittle. Even a slight bend or a fall to the deck may cause a file to snap in two. Do not strike a file against the bench or vise to clean it—use a file card.

Safety

Never use a file unless it is equipped with a tight-fitting handle. If you use a file without the handle and it bumps something or jams to a sudden stop, the tang may be driven into your hand. To put a handle on a file tang, drill a hole in the handle, slightly smaller than the tang. Insert the tang end, and then tap the end



44.20(11)CX
Figure 1-41.—Twist drill nomenclature.

of the handle to seat it firmly. Make sure you get the handle on straight.

TWIST DRILLS

Making a hole in a piece of metal is generally a simple operation, but in most cases is an important and a precise job. A large number of different tools and machines have been designed so that holes may be made speedily, economically, and accurately in all kinds of material.

In order to be able to use these tools efficiently, it is well to become acquainted with them. The most common tool for making holes in metal is the twist drill. It consists of a cylindrical piece of steel with spiral grooves. One end of the cylinder is pointed while the other end is shaped so that it may be attached to a drilling machine. The grooves, usually called FLUTES, may be cut into the steel cylinder, or the flutes may be formed by twisting a flat piece of steel into a cylindrical shape.

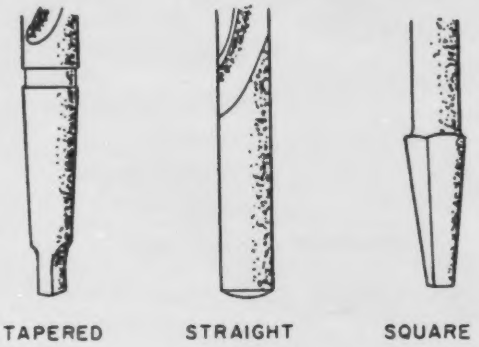
The principal parts of a twist drill are the body, the shank, and the point (fig. 1-41). The dead center of a drill is the sharp edge at the extreme tip end of the drill. It is formed by the intersection of the cone-shaped surfaces of the point and should always be in the exact center of the axis of the drill. The point of the drill should not be confused with the dead center. The point is the entire cone-shaped surface at the end of the drill.

The lip or cutting edge of a drill is that part of the point that actually cuts away the metal when drilling a hole. It is ordinarily as sharp as the edge of a knife. There is a cutting edge for each flute of the drill.

The lip clearance of a drill is the surface of the point that is ground away or relieved just back of the cutting edge of the drill. The strip along the inner edge of the body is called the margin. It is the greatest diameter of the drill and extends the entire length of the flute. The diameter of the margin at the shank end of the drill is smaller than the diameter at the point. This allows the drill to revolve without binding when drilling deep holes.

The shank is the part of the drill which fits into the socket, spindle, or chuck of the drill press. Several types exist (fig. 1-42).

A tang is found only on tapered-shank drills. It is designed to fit into a slot in the socket or spindle of a machine. It may bear a portion of the driving torque, but its principal use is to make it easy to remove the drill from the socket of the driving machine.



44.20(44B)
Figure 1-42.—Representative shanks.

Twist drills are provided in various sizes. They are sized by letters, numerals, and fractions.

Table 1-1 illustrates the relationship, by decimal equivalents, of all drill sizes (letter, number, and fractional) from number 80 to 1/2 inch. Note how the decimal sizes increase as the number of the drill decreases.

Sets of drills are usually made available according to the way the sizes are stated; that is "sets of letter drills" or "sets of number drills." However, twist drills of any size (letter, number, or fraction) are available individually if desired.

The maintenance of twist drills and more about how to use them on specific jobs are discussed later.

COUNTERSINKS

Countersinking is the operation of beveling the mouth of a hole with a rotary tool called a countersink (fig. 1-43). The construction of the countersink is similar to the twist drill. There are four cutting edges, which are taper ground, to the angle marked on the body.

A countersink is used primarily to set the head of a screw or rivet flush with the material in which it is being placed. Countersinks are made in a number of sizes. One size usually takes care of holes of several different sizes. That is, the same countersink can be used for holes from 1/4 inch to 1/2 inch in diameter. Remove only enough metal to set the screw or rivet head flush with the material. If you

Table 1-1.—Decimal Equivalents of Drill Sizes

Drill	Decimal	Drill	Decimal	Drill	Decimal	Drill	Decimal
80	0.0135	49	0.073	20	0.161	H	0.266
79	0.0145	48	0.076	19	0.166	I	0.272
78	0.016	5/64	0.078125	18	0.1695	J	0.277
1/64	0.0156	47	0.0785	11/64	0.171875	K	0.281
77	0.018	46	0.081	17	0.173	9/32	0.28125
76	0.02	45	0.082	16	0.177	L	0.29
75	0.021	44	0.086	15	0.18	M	0.295
74	0.0225	43	0.089	14	0.182	19/64	0.296875
73	0.024	42	0.0935	13	0.185	N	0.302
72	0.025	3/32	0.09375	3/16	0.1875	5/16	0.3125
71	0.026	41	0.096	12	0.189	O	0.316
70	0.028	40	0.098	11	0.191	P	0.323
69	0.0292	39	0.0995	10	0.1935	21/64	0.328125
68	0.031	38	0.1015	9	0.196	Q	0.332
1/32	0.03125	37	0.104	8	0.199	R	0.339
67	0.032	36	0.1055	7	0.201	11/32	0.34375
66	0.033	7/64	0.109375	13/64	0.203125	S	0.348
65	0.035	35	0.11	6	0.204	T	0.358
64	0.036	34	0.111	5	0.2055	23/64	0.359375
63	0.037	33	0.113	4	0.209	U	0.368
62	0.038	32	0.116	3	0.213	3/8	0.375
61	0.039	31	0.12	7/32	0.21875	V	0.377
60	0.04	1/8	0.125	2	0.221	W	0.386
59	0.041	30	0.1285	1	0.228	25/64	0.390625
58	0.042	29	0.136	A	0.234	X	0.397
57	0.043	28	0.1405	15/64	0.234375	Y	0.404
56	0.0465	9/64	0.140625	B	0.238	13/32	0.40625
3/64	0.046875	27	0.144	C	0.242	Z	0.413
55	0.052	26	0.147	D	0.246	27/64	0.421875
54	0.055	25	0.1495	E	0.25	7/16	0.4375
53	0.0595	24	0.152	1/4	0.25	29/64	0.453125
1/16	0.0625	23	0.154	F	0.257	15/32	0.46875
52	0.0635	5/32	0.15625	G	0.261	31/64	0.484375
51	0.067	22	0.157	17/64	0.265625	1/2	0.5
50	0.07	21	0.159				

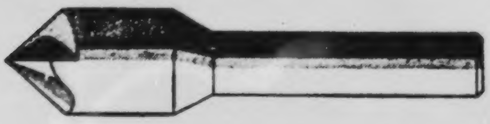
44.209

remove too much material the hole will enlarge and weaken the work.

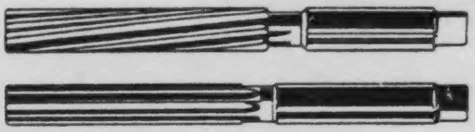
Select the countersink with the correct lip angle to correspond with the screw or rivet head being used. These countersinks can be turned by any machine that will turn a twist drill.

REAMERS

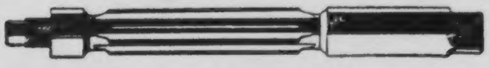
Reamers are used to enlarge and true a hole. The reamer consists of three parts—the body, the shank, and the blades. The shank has a square tang to allow the reamer to be held



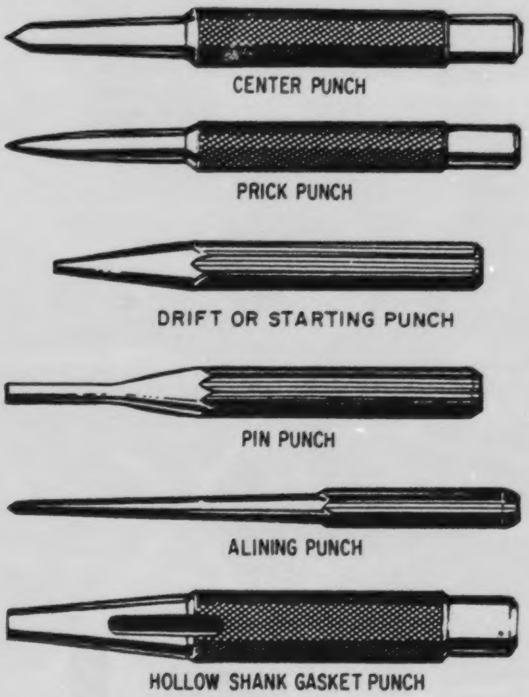
28.59(44)
Figure 1-43.—Countersink.



5.10.1
Figure 1-44.—Above—solid spiral flute reamer. Below—solid straight flute reamer.



5.10.2
Figure 1-45.—Expansion reamer.



1.18(44B)
Figure 1-46.—Punches.

with a wrench for turning. The main purpose of the body is to support the blades.

The blades on a reamer are made of steel and hardened to such an extent that they are brittle. For this reason you must be careful when using and storing the reamer to protect the blades from chipping. When you are reaming a hole, turn the reamer in the CUTTING DIRECTION ONLY. This will prevent chipping or dulling of the blades. Great care should be used to assure even, steady turning. Otherwise, the reamer will "chatter," causing the hole to become marked or scored. To prevent damage to the reamer while not in use, wrap it in an oily cloth and keep it in a box.

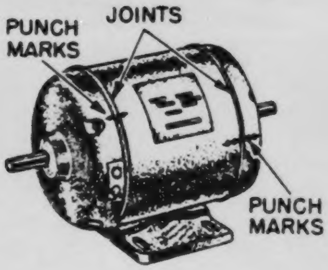
Reamers of the types shown in figure 1-44 are available in any standard size. They are also available in size variations of .001" for special work. A solid straight flute reamer lasts longer and is less expensive than the expansion reamer. However, the solid spiral flute reamer is preferred by craftsmen because it is less likely to chatter.

For general purposes, an expansion reamer (fig. 1-45) is the most practical. This reamer can usually be obtained in standard sizes from 1/4 of an inch to 1 inch, by 32nds. It is designed to allow the blades to expand 1/32 of an inch. For example, the 1/4-inch expansion reamer will ream a 1/4-inch to a 9/32-inch hole. A 9/32-inch reamer will enlarge the hole from 9/32 of an inch to 5/16 of an inch. This range of adjustment allows a few reamers to cover sizes up to 1 inch.

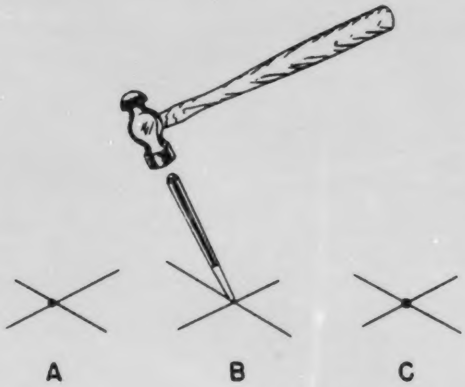
Reamers are made of carbon steel and high-speed steel. In general, the cutting blades of a high-speed reamer lose their keenness more quickly than a carbon steel reamer. However, after that keenness is gone, it will last longer than the carbon reamer.

PUNCHES

A hand punch is a tool that is held in the hand and struck on one end with a hammer. There are many kinds of punches designed to do a variety of jobs. Figure 1-46 shows several types of punches. Most punches are made of tool steel. The part held in the hand is usually octagonal shaped, or it may be knurled. This



28.32
Figure 1-47.—Punching mating parts of a mechanism.



44.83
Figure 1-48.—Marking the intersection of lines with a prick punch.

prevents the tool from slipping around in the hand. The other end is shaped to do a particular job.

When you use a punch, there are two things to remember:

1. When you hit the punch you do not want it to slip sideways over your work.
2. You do not want the hammer to slip off the punch and strike your fingers. You can eliminate both these troubles by holding the punch at right angles to the work, and striking the punch squarely with your hammer.

The center punch, as the name implies, is used for marking the center of a hole to be drilled. If you try to drill a hole without first punching the center, the drill will "wander" or "walk away" from the desired center.

Another use of the center punch is to make corresponding marks on two pieces of an assembly to permit reassembling in the original positions. Before taking a mechanism apart, make a pair of center punchmarks in one or more places to help in reassembly. To do this, select places, staggered as shown in figure 1-47, where matching pieces are joined. First clean the places selected. Then scribe a line across the joint and center punch the line on both sides of the joint, with single and double marks as shown to eliminate possible errors. In reassembly, refer first to the sets of punchmarks to determine the approximate position of the parts. Then line up the scribed lines to determine the exact position.

Automatic center punches are useful for layout work. They are operated by pressing down on the shank by hand. An inside spring is compressed and released automatically, striking a blow on the end of the punch. The impression is light, but adequate for marking, and serves to locate the point of a regular punch when a deeper impression is required.

The point of a center punch is accurately ground central with the shank, usually at a 60-90 degree angle, and is difficult to regrind by hand with any degree of accuracy. It is, therefore, advisable to take care of a center punch and not to use it on extremely hard materials. When extreme accuracy is required a prick punch is used. Compare the point angle of the center and prick punches.

To make the intersection of two layout lines, bring the point of the prick punch to the exact point of intersection and tap the punch lightly with a hammer. If inspection shows that the exact intersection and the punchmark do not coincide, as at A in figure 1-48, slant the punch as shown at B and again strike with the hammer, thus enlarging the punchmark and centering it exactly. When the intersection has been correctly punched, finish off with a light blow on the punch held in an upright position. C shows the corrected punchmark.

DRIFT punches, sometimes called "starting punches," have a long taper from the tip to the body. They are made that way to withstand the shock of heavy blows. They may be used for knocking out rivets after the heads have been chiseled off, or for freeing pins which are "frozen" in their holes.

After a pin has been loosened or partially driven out, the drift punch may be too large to finish the job. The followup tool to use is the PIN PUNCH. It is designed to follow through the hole without jamming. Always use the largest drift or pin punch that will fit the hole. These punches usually come in sets of three to five assorted sizes. Both of these punches will have flat points, never edged or rounded.

To remove a bolt or pin that is extremely tight, start with a drift punch that has a point diameter that is slightly smaller than the diameter of the object you are removing. As soon as it loosens, finish driving it out with a pin punch. Never use a pin punch for starting a pin because it has a slim shank and a hard blow may cause it to bend or break.

For assembling units of a machine an ALINEMENT (alining) punch is invaluable. It is usually about 1 foot long and has a long gradual taper. Its purpose is to line up holes in mating parts.

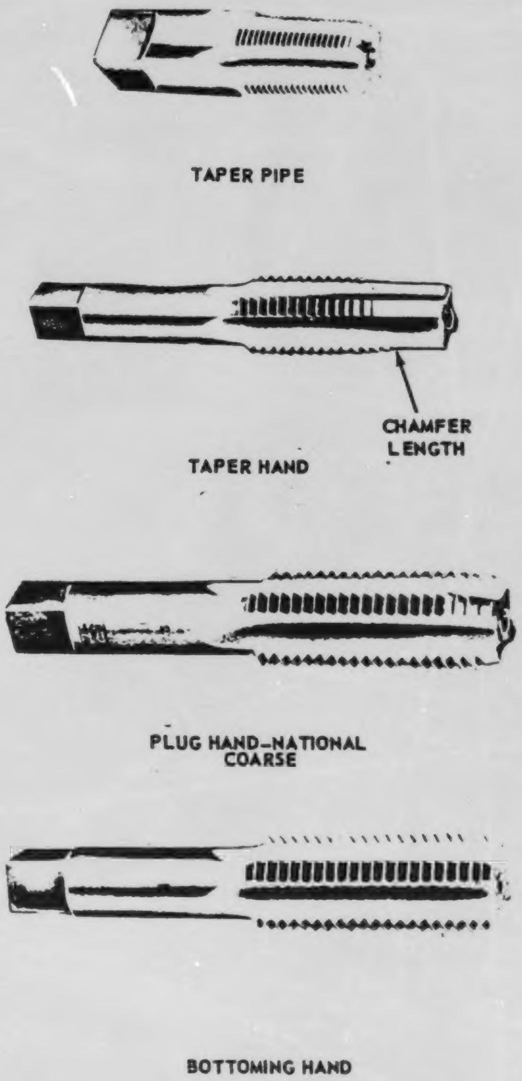
Hollow metal cutting punches are made from hardened tool steel. They are made in various sizes and are used to cut holes in light gage sheet metal.

Other punches have been designed for special uses. One of these is the soft-faced drift. It is made of brass or fiber and is used for such jobs as removing shafts, bearings, and wrist pins from engines. It is generally heavy enough to resist damage to itself, but soft enough not to injure the finished surface on the part that is being driven.

You may have to make gaskets of rubber, cork, leather, or composition materials. For cutting holes in gasket materials a hollow shank GASKET PUNCH may be used (fig. 1-46). Gasket punches come in sets of various sizes to accommodate standard bolts and studs. The cutting end is tapered to a sharp edge to produce a clean uniform hole. To use the gasket punch, place the gasket material to be cut on a piece of hard wood or lead so that the cutting edge of the punch will not be damaged. Then strike the punch with a hammer, driving it through the gasket where holes are required.

TAPS AND DIES

Taps and dies are used to cut threads in metal, plastics, or hard rubber. The taps are used for cutting internal threads, and the dies are used to cut external threads. There are many different types of taps. However, the most common are the taper, plug, bottoming, and pipe taps (fig. 1-49).



11.5.1

Figure 1-49.—Types of common taps.

The taper (starting) hand tap has a chamfer length of 8 to 10 threads. These taps are used when starting a tapping operation and when tapping through holes.

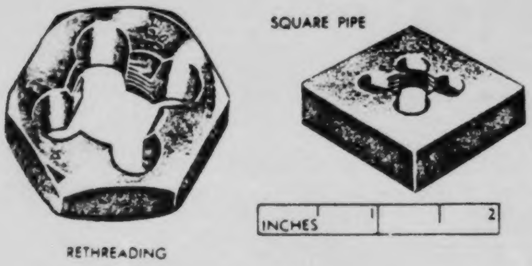

SQUARE PIPE
INCHES
1
2
RETHREADING

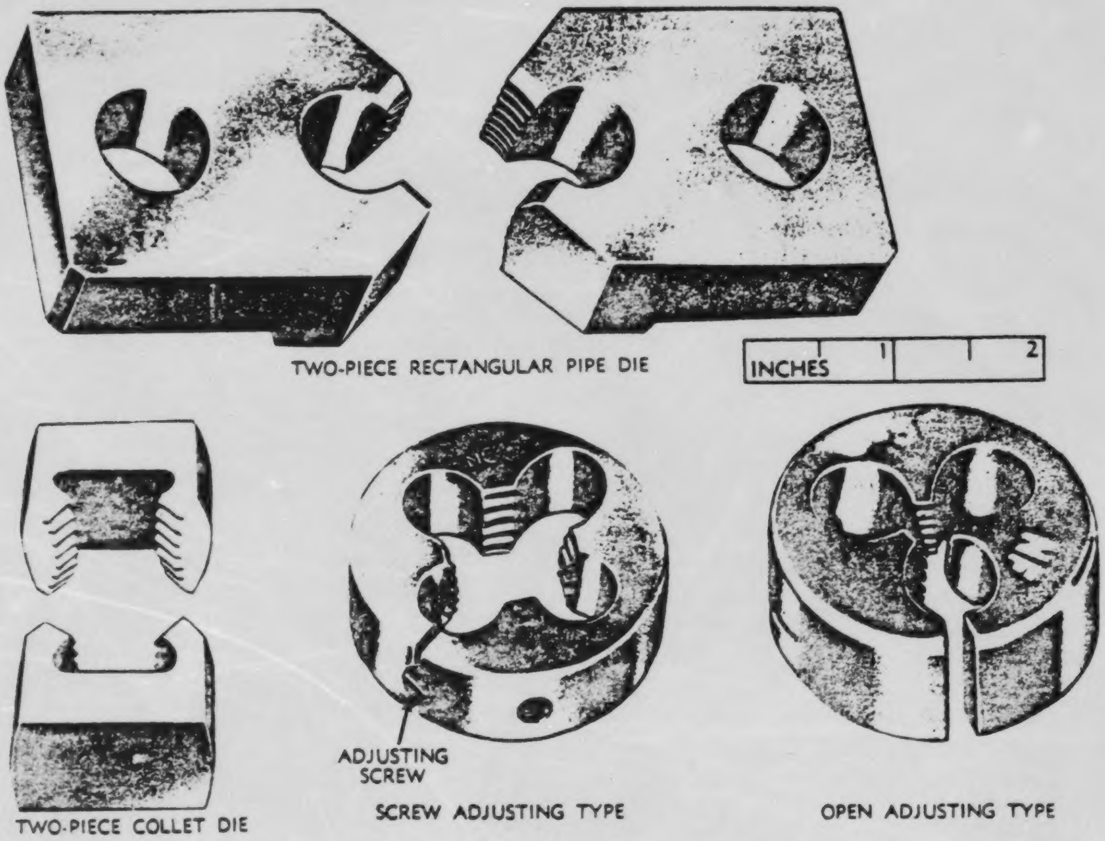
Figure 1-50.—Types of solid dies. 11.5.4

Plug hand taps have a chamfer length of 3 to 5 threads and are designed for use after the taper tap.

Bottoming hand taps are used for threading the bottom of a blind hole. They have a very short chamfer length of only 1 to 1 1/2 threads for this purpose. This tap is always used after the plug tap has already been used. Both the taper and plug taps should precede the use of the bottoming hand tap.

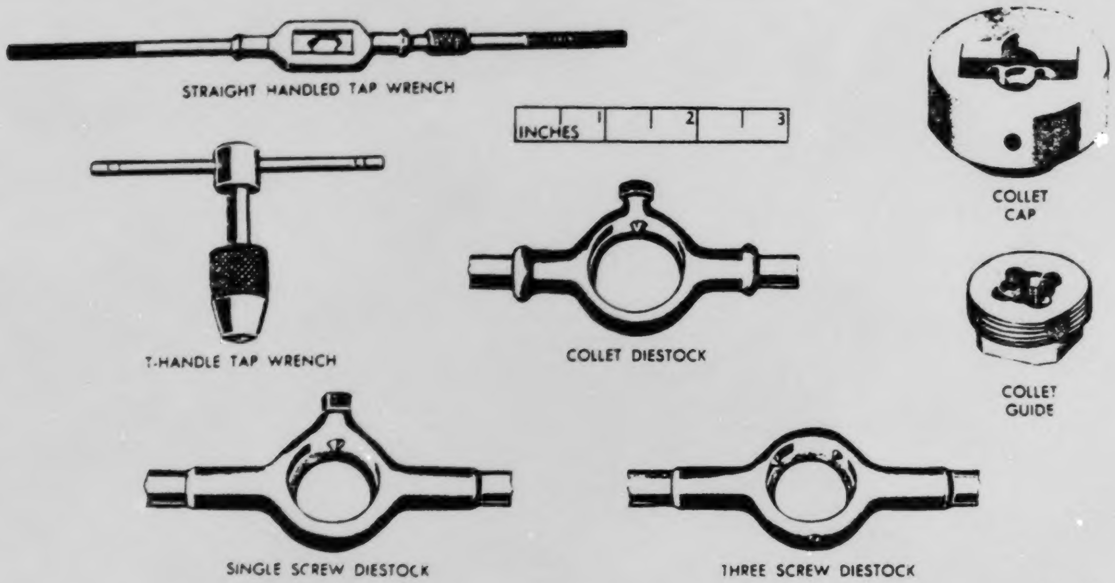
Pipe taps are used for pipe fittings and other places where extremely tight fits are necessary. The tap diameter, from end to end of threaded portion, increases at the rate of 3/4 inch per foot. All the threads on this tap do the cutting, as compared to the straight taps where only the nonchamfered portion does the cutting.

Dies are made in several different shapes and are of the solid or adjustable type. The square pipe die (fig. 1-50) will cut American Standard Pipe Thread only. It comes in a variety of sizes for cutting threads on pipe with diameters of 1/8 inch to 2 inches.


TWO-PIECE RECTANGULAR PIPE DIE
INCHES
1
2
ADJUSTING SCREW
TWO-PIECE COLLET DIE
SCREW ADJUSTING TYPE
OPEN ADJUSTING TYPE

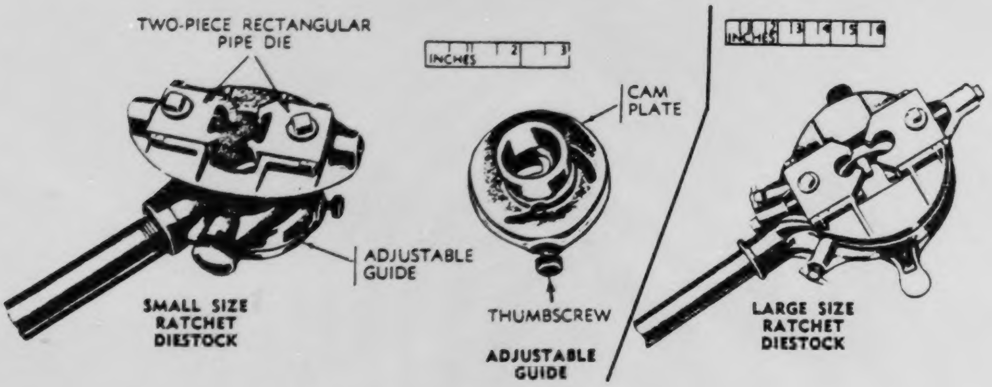
11.5.2

Figure 1-51.—Types of adjustable dies.


STRAIGHT HANDLED TAP WRENCH
INCHES
1
2
3
COLLET CAP
T-HANDLE TAP WRENCH
COLLET DIESTOCK
COLLET GUIDE
SINGLE SCREW DIESTOCK
THREE SCREW DIESTOCK

11.5.6

Figure 1-52.—Diestocks, diecollet, and tap wrenches.

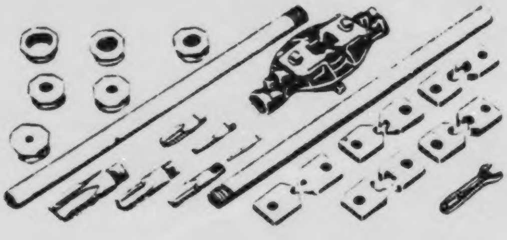

TWO-PIECE RECTANGULAR PIPE DIE
INCHES
CAM PLATE
ADJUSTABLE GUIDE
SMALL SIZE RATCHET DIESTOCK
THUMBSCREW
ADJUSTABLE GUIDE
LARGE SIZE RATCHET DIESTOCK

44.31

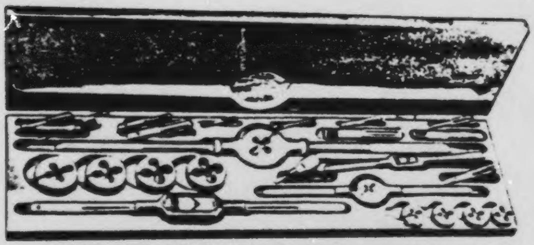
Figure 1-53.—Adjustable die guide and ratchet diestocks.

A rethreading die (fig. 1-50) is used principally for dressing over bruised or rusty threads on screws or bolts. It is available in a variety of sizes for rethreading American Standard Coarse and Fine threads. These dies are usually hexagon in shape and can be turned with a socket, box, open-end, or any wrench that will fit. Rethreading dies are available in sets of 6, 10, 14, and 28 assorted sizes in a case.

Round split adjustable dies (fig. 1-51) are called "Button" dies and can be used in either hand diestocks or machine holders. The adjustment in the screw adjusting type is made by a fine-pitch screw which forces the sides of the die apart or allows them to spring together. The adjustment in the open adjusting types is made by means of three screws in the holder, one for expanding and two for compressing the



PIPE THREADING SET WITH RECTANGULAR ADJUSTABLE DIES, DIESTOCK, WRENCH, GUIDES AND TAPS



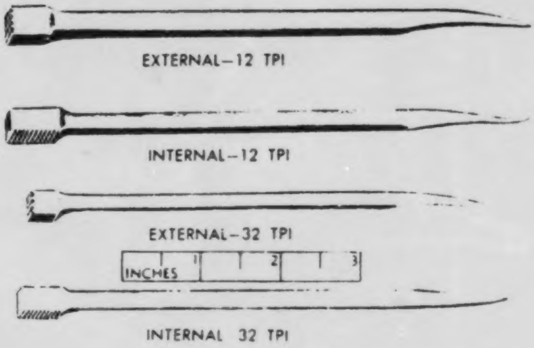
BOLT AND SCREW THREADING SET WITH ROUND ADJUSTABLE SPLIT DIES, DIESTOCKS, TAPS, TAP WRENCHES, AND SCREWDRIVERS

44.32

Figure 1-54.—Threading sets.

dies. Round split adjustable dies are available in a variety of sizes to cut American Standard Coarse and Fine threads, special form threads, and the standard sizes of threads that are used in Britain and other European countries. For hand threading, these dies are held in diestocks (fig. 1-52). One type die stock has three pointed screws that will hold round dies of any construction, although it is made specifically for open adjusting-type dies.

Two piece collet dies (fig. 1-51) are used with a collet cap (fig. 1-52) and collet guide. The die halves are placed in the cap slot and are held in place by the guide which screws into the underside of the cap. The die is adjusted by means of setscrews at both ends of the internal slot. This type of adjustable die is issued in various sizes to cover the cutting range of American Standard Coarse and Fine and special form threads. Diestocks to hold the dies come in three different sizes.



44.33

Figure 1-55.—Thread chasers.

Two-piece rectangular pipe dies (fig. 1-51) are available to cut American Standard Pipe threads. They are held in ordinary or ratchet-type diestocks (fig. 1-53). The jaws of the dies are adjusted by means of setscrews. An adjustable guide serves to keep the pipe in alinement with respect to the dies. The smooth jaws of the guide are adjusted by means of a cam plate; a thumbscrew locks the jaws firmly in the desired position.

Threading sets are available in many different combinations of taps and dies, together with diestocks, tap wrenches, guides and necessary screwdrivers and wrenches to loosen and tighten adjusting screws and bolts. Figure 1-54 illustrates typical threading set for pipe, bolts, and screws.

Never attempt to sharpen taps or dies. Sharpening of taps and dies involves several highly precise cutting processes which involve the thread characteristics and chamfer. These sharpening procedures must be done by experienced personnel in order to maintain the accuracy and the cutting effectiveness of taps and dies.

Keep taps and dies clean and well oiled when not in use. Store them so that they do not contact each other or other tools. For long periods of storage, coat taps and dies with a rust-preventive compound, place in individual or standard threading set boxes, and store in a dry place.

THREAD CHASERS

Thread chasers are threading tools that have several teeth and are used to rethread (chase) damaged external or internal threads (fig. 1-55). These tools are available to chase standard threads. The internal thread chaser has its cutting teeth located on a side face. The external thread chaser has its cutting teeth on the end of the shaft. The handle end of the tool shaft tapers to a point.

SCREW AND TAP EXTRACTORS

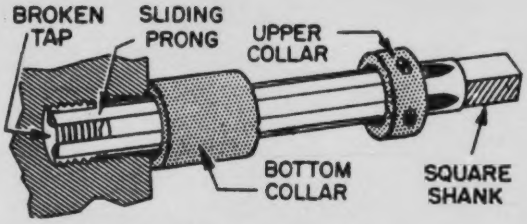
Screw extractors are used to remove broken screws without damaging the surrounding material or the threaded hole. Tap extractors are used to remove broken taps.

Some screw extractors (fig. 1-56A) are straight, having flutes from end to end. These extractors are available in sizes to remove broken screws having 1/4 to 1/2 inch outside diameters. Spiral tapered extractors are sized to remove screws and bolts from 3/16 inch to 2 1/8 inches outside diameter.

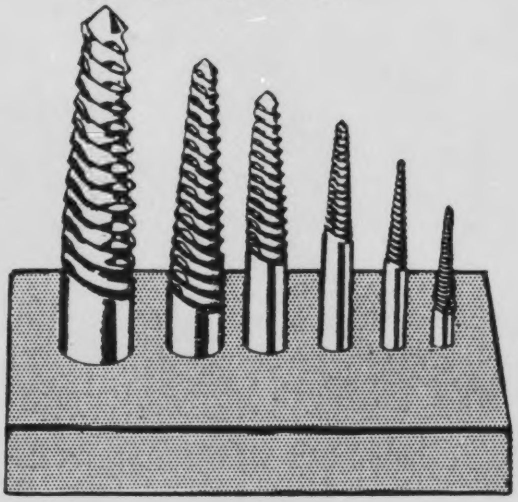
Most sets of extractors include twist drills and a drill guide. Tap extractors are similar to the screw extractors and are sized to remove taps ranging from 3/16 to 2 1/8 inches outside diameter.

To remove a broken screw or tap with a spiral extractor, first drill a hole of proper size in the screw or tap. The size hole required for each screw extractor is stamped on it. The extractor is then inserted in the hole, and turned counterclockwise to remove the defective component.

If the tap has broken off at the surface of the work, or slightly below the surface of the work, the straight tap extractor shown in figure 1-56 may remove it. Apply a liberal amount of penetrating oil to the broken tap. Place the tap extractor over the broken tap and lower the upper collar to insert the four sliding prongs down into the four flutes of the tap. Then slide the bottom collar down to the surface of the work so that it will hold the prongs tightly against the body of the extractor. Tighten the tap wrench on the square shank of the extractor and carefully work the extractor back and forth to loosen the tap. It may be necessary to remove the extractor and strike a few sharp blows with a small hammer and pin punch to jar the tap loose. Then reinsert the tap remover and carefully try to back the tap out of the hole.



A. STRAIGHT TAP



B. SPIRAL SCREW

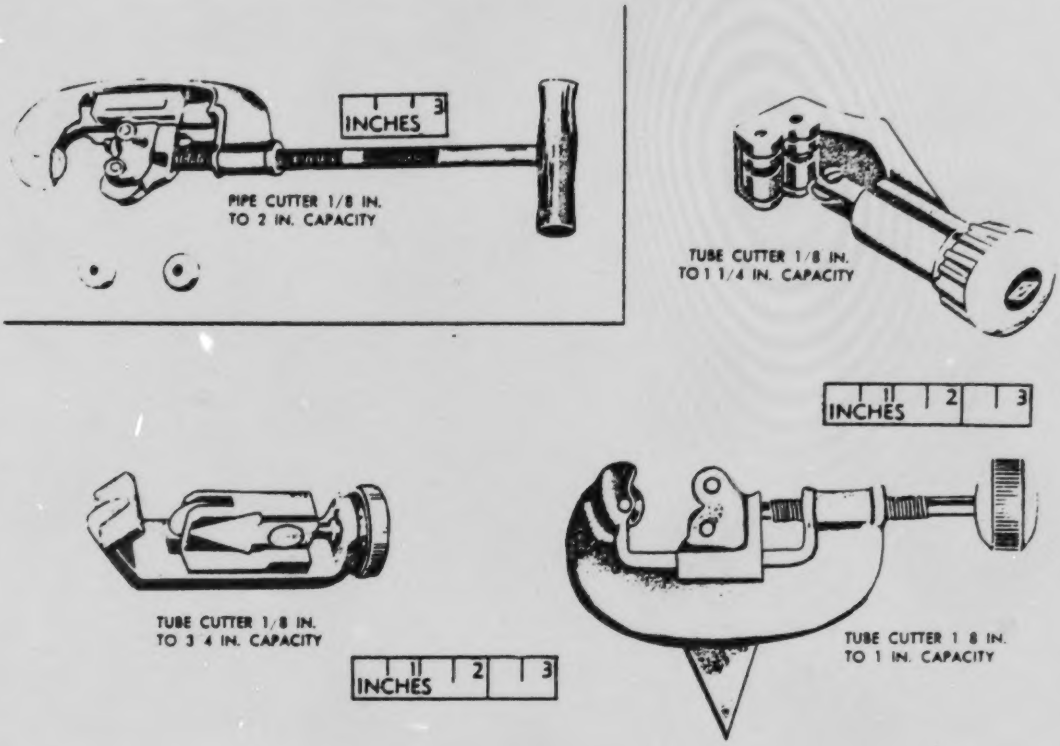
4.37:44.191

Figure 1-56.—Screw and tap extractors.

PIPE AND TUBING CUTTERS AND FLARING TOOLS

Pipe cutters (fig. 1-57) are used to cut pipe made of steel, brass, copper, wrought iron, and lead. Tube cutters (fig. 1-57) are used to cut tubing made of iron, steel, brass, copper, and aluminum. The essential difference between pipe and tubing is that tubing has considerably thinner walls. Flaring tools (fig. 1-58) are used to make single or double flares in the ends of tubing.

Two sizes of hand pipe cutters are generally used in the Navy. The No. 1 pipe cutter has a cutting capacity of 1/8 to 2 inches, and the No. 2 pipe cutter has a cutting capacity of 2 to 4



44.36

Figure 1-57.—Pipe and tubing cutters.

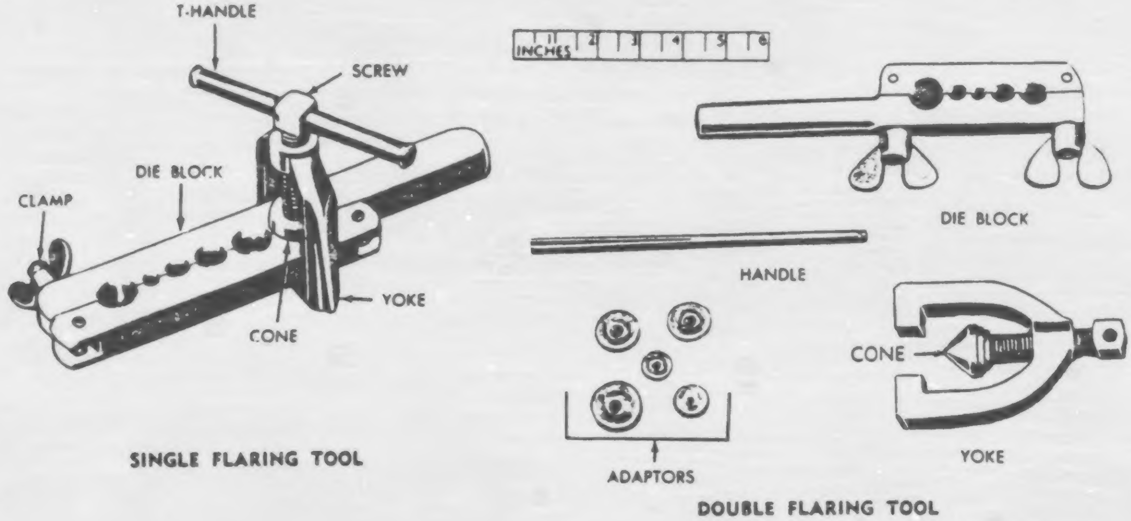
inches. The pipe cutter (fig. 1-57) has a special alloy-steel cutting wheel and two pressure rollers which are adjusted and tightened by turning the handle.

Most TUBE CUTTERS closely resemble pipe cutters, except that they are of lighter construction. A hand screw feed tubing cutter of 1/8-inch to 1 1/4-inch capacity (fig. 1-57) has two rollers with cutouts located off center so that cracked flares may be held in them and cut off without waste of tubing. It also has a retractable cutter blade that is adjusted by turning a knob. The other tube cutter shown is designed to cut tubing up to and including 3/4 and 1 inch outside diameter. Rotation of the triangular portion of the tube cutter within the tubing will eliminate any burrs.

FLARING TOOLS (fig. 1-58) are used to flare soft copper, brass, or aluminum. The single flaring tool consists of a split die block that has holes for 3/16-, 1/4-, 5/16-, 3/8-, 7/16-, and 1/2-inch outer diameter (o.d.) tubing, a clamp to lock the tube in the die block, and a yoke that slips over the die block and has a compressor screw and a cone that forms a 45° flare or a bell shape on the end of the tube. The screw has a T-handle. A double flaring tool has the additional feature of adapters that turn in the edge of the tube before a regular 45° double flare is made. It consists of a die block with holes for 3/16-, 1/4-, 5/16-, 3/8-, and 1/2-inch tubing, a yoke with a screw and a flaring cone, plus five adapters for different size tubing, all carried in a metal case.

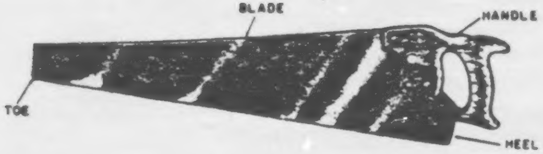
WOODCUTTING HANDTOOLS

A man working with wood uses a large variety of handtools. He should be familiar with these tools, their proper names, the purpose for which they are used, and how to keep them in good condition.


T-HANDLE
SCREW
DIE BLOCK
CLAMP
YOKE
CONE
SINGLE FLARING TOOL
INCHES 1 2 3 4 5 6
DIE BLOCK
HANDLE
CONE
ADAPTORS
YOKE
DOUBLE FLARING TOOL

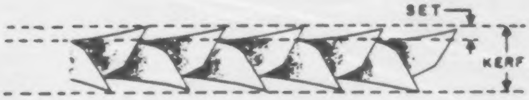
44.37

Figure 1-58.—Flaring tools.


BLADE
HANDLE
TOE
HEEL

29.15(44)

Figure 1-59.—Nomenclature of a handsaw.



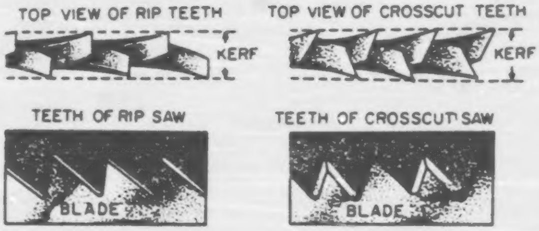
29.15A

Figure 1-60.—"Set" of hand saw teeth.

In this section of the text, only the basic woodcutting tools are covered. It includes tools that any man in the Navy may have the occasion to use during his career.

HANDSAWS

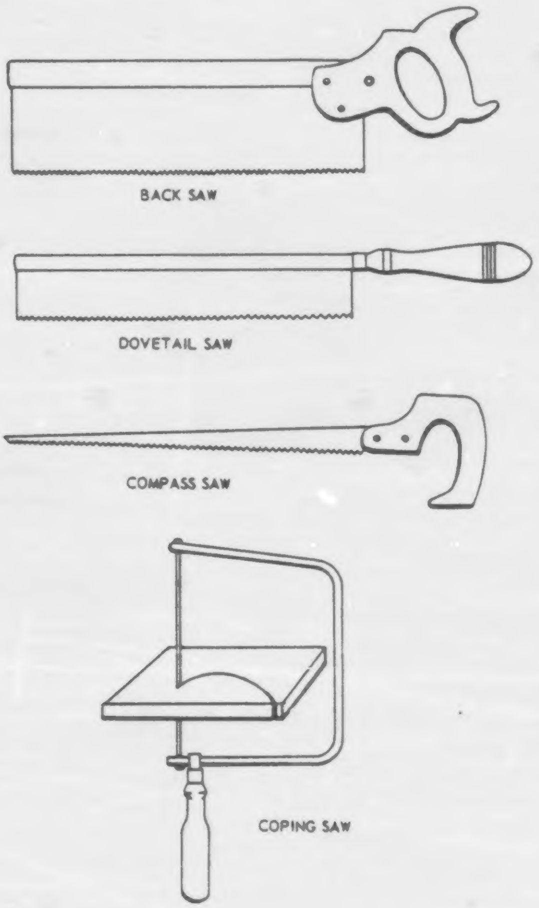
The most common carpenter's handsaw consists of a steel blade with a handle at one end.


TOP VIEW OF RIP TEETH
KERF
TOP VIEW OF CROSSCUT TEETH
KERF
TEETH OF RIP SAW
BLADE
TEETH OF CROSSCUT SAW
BLADE

29.15(44B)

Figure 1-61.—Comparing rip and crosscut-saw teeth.

The blade is narrower at the end opposite the handle. This end of the blade is called the "point" or "toe." The end of the blade nearest the handle is called the "heel" (fig. 1-59). One edge of the blade has teeth, which act as two rows of cutters. When the saw is used, these teeth cut two parallel grooves close together. The chips (sawdust) are pushed out from between the grooves (kerf) by the beveled part of the teeth. The teeth are bent alternately to one side or the other, to make the kerf wider than the thickness of the blade. This bending is called the "set" of the teeth (fig. 1-60). The number of teeth per inch, the size and shape of the teeth, and the amount of set depend on the



29.20-.22

Figure 1-62.—Special saws.

use to be made of the saw and the material to be cut. Carpenter's handsaws are described by the number of points per inch. By custom, there is always one more point than there are teeth per inch. A number stamped near the handle gives the number of points of the saw.

Cross-cut and Rip Saws

Woodworking handsaws designed for general cutting consist of RIPSAWS and CROSSCUT saws. Ripsaws are used for cutting with the grain and crosscut saws are for cutting across the grain.

The major difference between a ripsaw and a crosscut saw is the shape of the teeth. A tooth with a square-faced chisel-type cutting edge, like the ripsaw tooth shown in figure 1-61, does a good job of cutting with the grain (called ripping), but a poor job of cutting across the grain (called crosscutting). A tooth with a beveled, knifetype cutting edge, like the crosscut saw tooth shown in the same figure, does a good job of cutting across the grain, but a poor job of cutting with the grain.

Special Purpose Saws

The more common types of saws used for special purposes are shown in figure 1-62. The BACKSAW is a crosscut saw designed for sawing a perfectly straight line across the face of a piece of stock. A heavy steel backing along the top of the blade keeps the blade perfectly straight.

The DOVETAIL saw is a special type of backsaw with a thin, narrow blade and a chisel-type handle.

The COMPASS saw is a long, narrow, tapering ripsaw designed for cutting out circular or other nonrectangular sections from within the margins of a board or panel. A hole is bored near the cutting line to start the saw. A KEYHOLE saw is simply a finer, narrower compass saw.

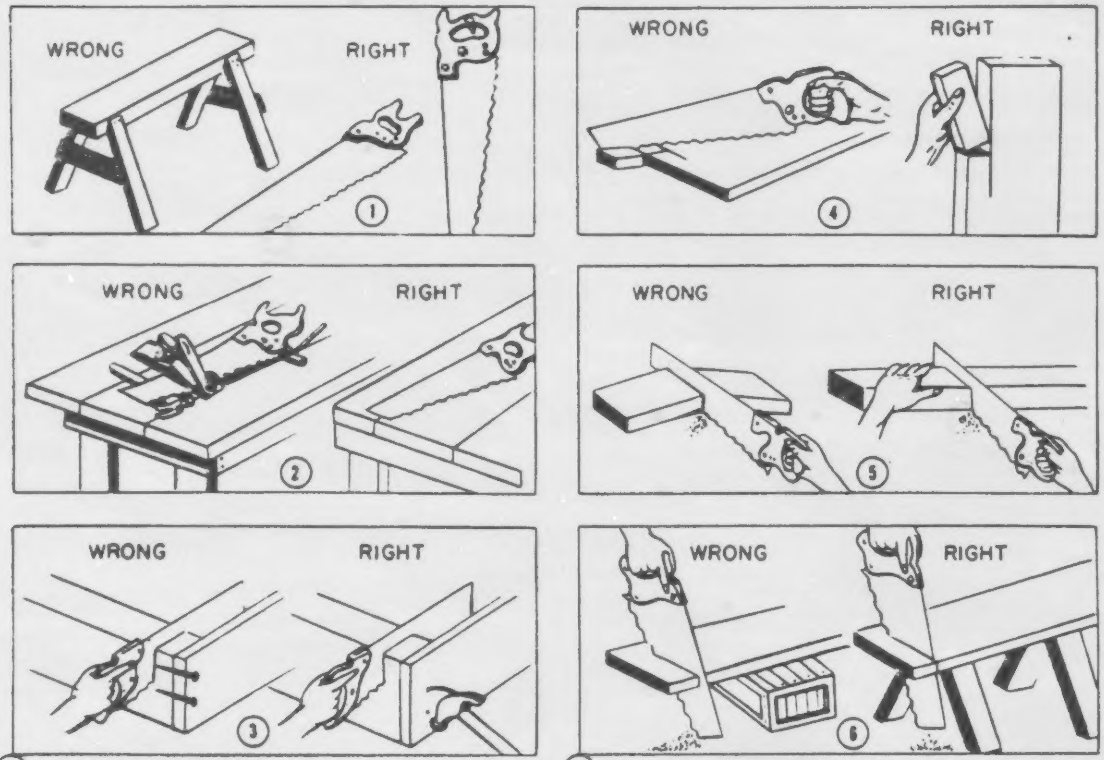
The COPING saw is used to cut along curved lines as shown in figure 1-62.

Saw Precautions

A saw that is not being used should be hung up or stowed in a toolbox. A toolbox designed for holding saws has notches that hold them on edge, teeth up. Stowing saws loose in a toolbox may allow the saw teeth to become dulled or bent by contacting other tools. Some right and wrong methods of using and caring for a saw are shown in figure 1-63. Be sure to read the captions for each section of the illustration.

Before using a saw, be sure there are no nails or other edge-destroying objects in the line of the cut. When sawing out a strip of waste, do not break out the strip by twisting the saw blade. This dulls the saw and may spring or break the blade.

Be sure that the saw will go through the full stroke without striking the floor or some other object. If the work cannot be raised high enough



① WHEN WORK IS COMPLETE, HANG UP THE SAW.

② DO NOT PILE TOOLS ON TOP OF THE BENCH SO AS TO DISTORT BLADE

③ LOOK CAREFULLY OVER REPAIR OR ALTERATION WORK; SEE THAT ALL NAILS ARE REMOVED TO AVOID CUTTING INTO METAL

④ STRIPS OF WASTE SHOULD NOT BE TWISTED OFF WITH BLADE, BUT BROKEN OFF WITH HAND OR MALLET.

⑤ SUPPORTING THE WASTE SIDE OF WORK WILL PREVENT SPLITTING OFF.

⑥ RAISE THE WORK TO A HEIGHT SUFFICIENT TO KEEP THE BLADE FROM STRIKING THE FLOOR. IF THE WORK CANNOT BE RAISED, LIMIT THE STROKE.

44.14

Figure 1-63.—Care of handsaws.

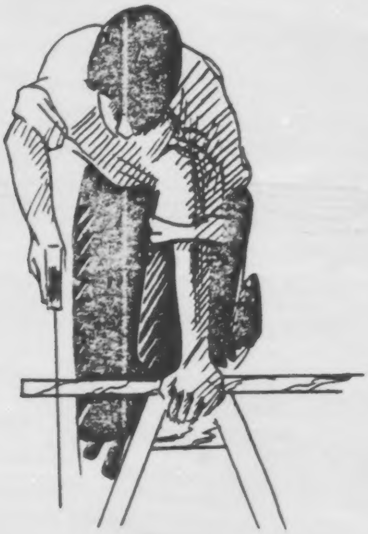
to obtain full clearance for the saw, you must carefully limit the length of each stroke.

Using A Hand Saw

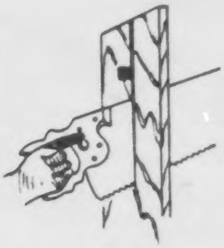
To saw across the grain of the stock, use the crosscut saw, and to saw with the grain, use a ripsaw. Study the teeth in both kinds of saws so you can readily identify the saw that you need.

Place the board on a saw horse (fig. 1-64), or some other suitable object. Hold the saw in the right hand and extend the first finger along the handle as shown in the figure. Grasp the board as shown and take a position so that an imaginary line passing lengthwise of the right forearm will be at an angle of approximately 45 degrees with the face of the board. Be sure the side of the saw is plumb or at right angles with the face of the board. Place the heel of the saw on the mark. Keep the saw in line with the forearm and pull it toward you to start the cut.

To begin with, take short, light strokes, gradually increasing the strokes to the full length of the saw. Do not force or jerk the saw. Such procedure will only make sawing more difficult. The arm that does the sawing should swing clear of your body so that the handle of



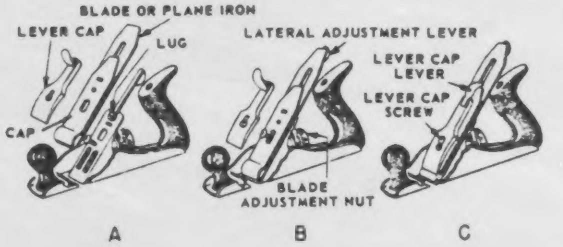
44.101
Figure 1-64.—Proper position for sawing a board to size.



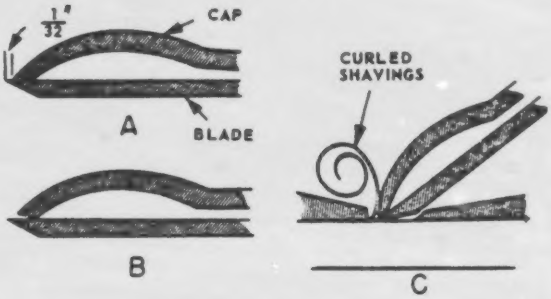
44.102
Figure 1-65.—Using a wedge in a saw kerf to prevent binding.

the saw operates at your side rather than in front of you.

Use one hand to operate the saw. You may be tempted to use both hands at times, but if your saw is sharp, one hand will serve you better. The weight of the saw is sufficient to make it cut. Should the saw stick or bind, it may be because the saw is dull and is poorly "set." The wood may have too much moisture in it, or you may have forced the saw and thus have caused it to leave the straight line.



29.12A
Figure 1-66.—Parts of a bench plane.



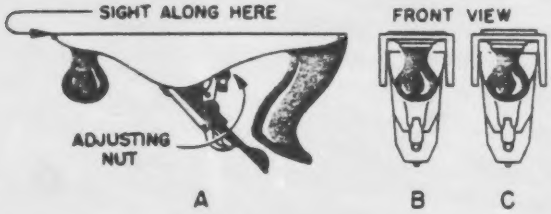
29.12B
Figure 1-67.—Plane iron and plane iron cap.

Keep your eye on the line rather than on the saw while sawing. Watching the line enables you to see instantly any tendency to leave the line. A slight twist of the handle, and taking short strokes while sawing, will bring the saw back. Blow away the sawdust frequently so you can see the layout line.

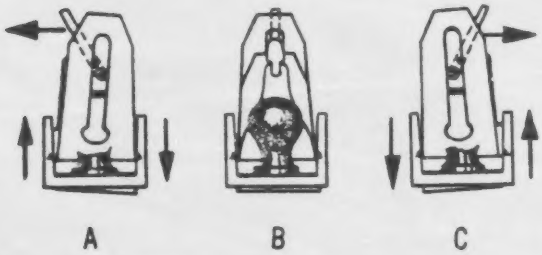
Final strokes of the cut should be taken slowly. Hold the waste piece in your other hand so the stock will not split when taking the last stroke.

Short boards may be placed on one sawhorse when sawing. Place long boards on two sawhorses, but do not saw so your weight falls between them or your saw will bind. Place long boards so that your weight is directly on one end of the board over one sawhorse while the other end of the board rests on the other sawhorse.

Short pieces of stock are more easily cut when they are held in a vise. When ripping short stock it is important that you keep the saw from sticking, so it may be necessary to take a squatting position. The saw can then take



29.12C
Figure 1-68.—Manipulation of the adjusting nut moves the plane iron up or down.



29.12D
Figure 1-69.—Effect of manipulation of the lateral adjustment lever.

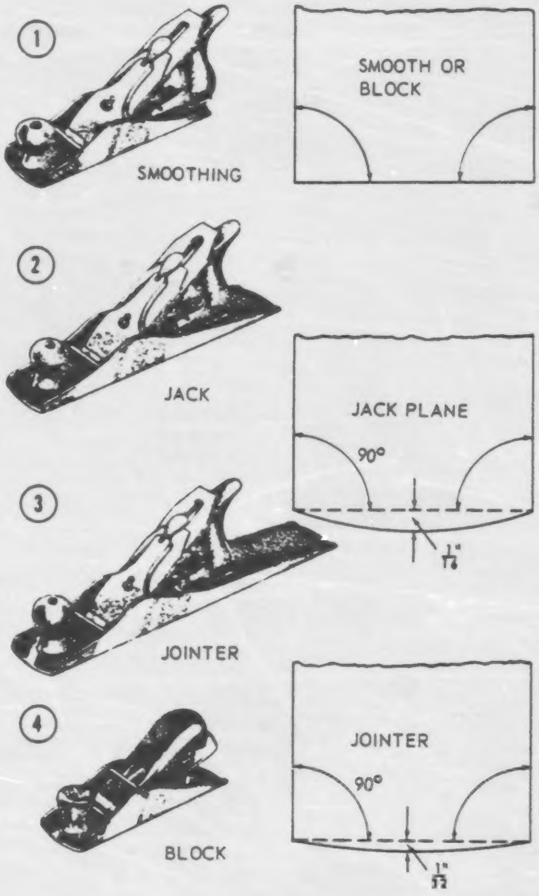
upward direction and thus work easily. When ripping long boards it will probably be necessary to use a wedge in the saw kerf to prevent binding (fig. 1-65).

PLANES

The plane is the most extensively used of the hand shaving tools. Most of the lumber handled by anyone working with wood is dressed on all four sides, but when performing jobs such as fitting doors and sash, and interior trim work, planes must be used.

Bench and block planes are designed for general surface smoothing and squaring. Other planes are designed for special types of surface work.

The principal parts of a bench plane and the manner in which they are assembled, are shown in figure 1-66. The part at the rear that you grasp to push the plane ahead is called the handle; the part at the front that you grasp to guide the plane along its course is called the knob. The main body of the plane, consisting of the bottom, the sides, and the sloping part which carries the plane iron, is called the frame. The bottom of the frame is called the sole, and the opening in the sole, through which the blade emerges, is called the mouth. The front end of the sole is called the toe; the rear end, the heel.



29.12
Figure 1-70.—Types of bench planes and block plane.

A plane iron cap, which is screwed to the upper face of the plane iron, deflects the shaving upward through the mouth, as indicated in figure 1-67C, and thus prevents the mouth from becoming choked with jammed shavings. The edge of the cap should fit the back of the iron as shown in figure 1-67A, not as shown in figure 1-67B. The lower end of the plane iron cap should be set back 1/32 in. from the edge of the plane top, as shown in figure 1-67A. The iron in a bench plane goes in bevel-down.

The edge of the plane iron is brought into correct cutting position by the manipulation of first the ADJUSTING NUT and next the LATERAL ADJUSTMENT LEVER, as shown in figures 1-68 and 1-69. The adjusting nut moves the edge of the iron up or down; the lateral adjustment lever cants it to the right or left. To adjust the plane you hold it upside-down, sight along the sole from the toe, and work the adjusting nut until the edge of the blade appears. Then work the lateral adjustment lever until the edge of the blade is in perfect alinement with the sole, as shown in figures 1-68B and 1-69B. Then use the adjusting nut to give the blade the amount of protrusion you want. This amount will depend, of course, upon the depth of the cut you intend to make.

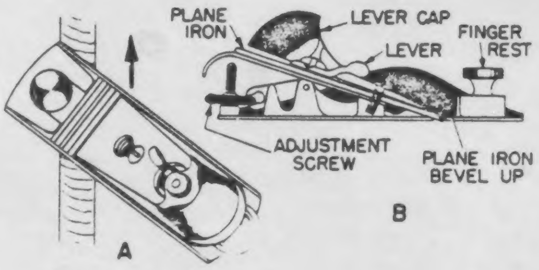
There are three types of bench planes (fig. 1-70): the SMOOTH plane, the JACK plane, and the JOINTER plane (sometimes called the FORE plane or the GAGE plane). All are used primarily for shaving and smoothing with the grain; the chief difference is the length of the sole. The sole of the smooth plane is about 9 in. long, the sole of the jack plane about 14 in. long, and the sole of the jointer plane from 20 to 24 in. long.

The longer the sole of the plane is, the more uniformly flat and true the planed surface will be. Consequently, which bench plane you should use depends upon the requirements with regard to surface trueness. The smooth plane is, in general, smoother only; it will plane a smooth, but not an especially true surface in a short time. It is also used for cross-grain smoothing and squaring of end-stock.

The jack plane is the general "jack-of-all-work" of the bench plane group. It can take a deeper cut and plane a truer surface than the smooth plane. The jointer plane is used when the planed surface must meet the highest requirements with regard to trueness.

A BLOCK PLANE and the names of its parts are shown in figure 1-71. Note that the plane iron in a block plane does not have a plane iron cap, and also that, unlike the iron in a bench plane, the iron in a block plane goes in bevel-up.

The block plane, which is usually held at an angle to the work, is used chiefly for cross-grain squaring of end-stock. It is also useful, however, for smoothing all plane surfaces on very small work.



29.12E

Figure 1-71.—Block plane nomenclature.

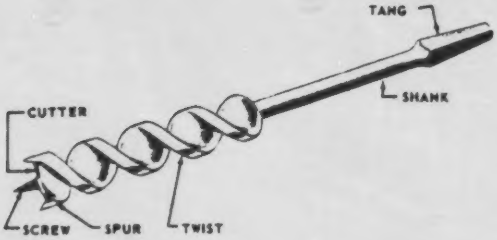
BORING TOOLS

When working with wood, you will frequently be required to bore holes. It is important, therefore, that you know the proper procedures and tools used for this job. Auger bits and a variety of braces and drills are used extensively for boring purposes.

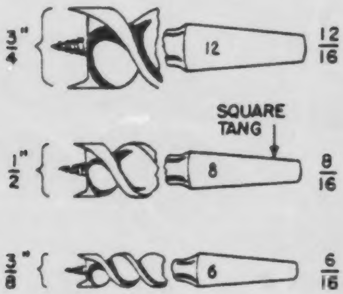
Auger Bits

Bits are used for boring holes for screws, dowels, and hardware, as an aid in mortising (cutting a cavity in wood for joining members) and in shaping curves and for many other purposes. Like saws and planes, bits vary in shape and structure with the type of job to be done. Some of the most common bits are described in this section.

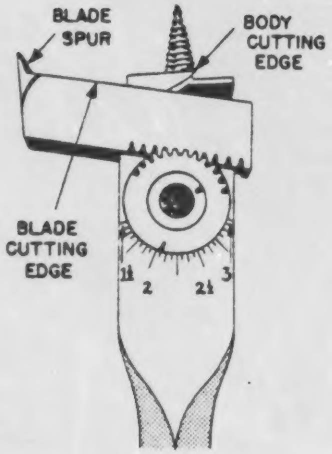
AUGER bits are screw-shaped tools consisting of six parts: the cutter, screw, spur, twist, shank, and tang (fig. 1-72). The twist ends with two sharp points called the spurs, which score the circle, and two cutting edges which cut shavings within the scored circle. The screw centers the bit and draws it into the wood. The threads of the screw are made in three different pitches: steep, medium, and fine. The steep pitch makes for quick boring and thick chips, and the fine or slight pitch makes for slow boring and fine chips. For end-wood boring, a steep- or medium-pitch screw bit should be used because end wood is likely to be forced in between the fine screw threads, and that will prevent the screw from taking


TANG
SHANK
CUTTER
SCREW
SPUR
TWIST

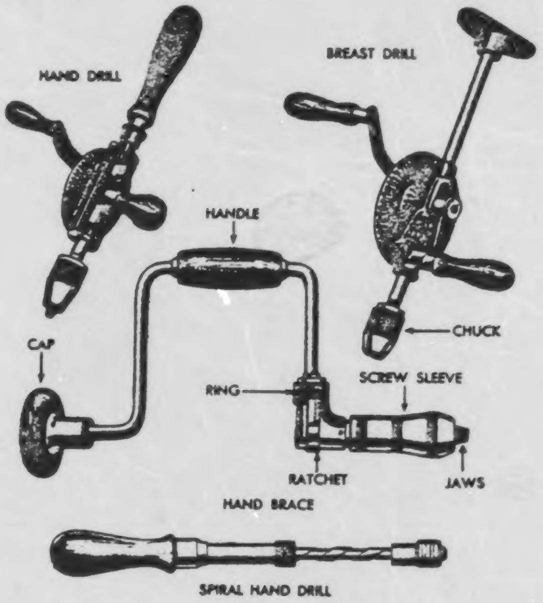
44.20
Figure 1-72.—Nomenclature of an auger bit.


3/4"
12
12/16
SQUARE TANG
1/2"
8
8/16
3/8"
6
6/16

44.20F
Figure 1-73.—Size markings on auger bits.


BLADE SPUR
BODY CUTTING EDGE
BLADE CUTTING EDGE
1½
2
2½
3

44.21A
Figure 1-74.—Expansive bit.


HAND DRILL
BREAST DRILL
HANDLE
CAP
CHUCK
SCREW SLEEVE
RING
RATCHET
JAWS
HAND BRACE
SPIRAL HAND DRILL

4.33:44.20(44B)
Figure 1-75.—Brace and drills.

hold. The twist carries the cuttings away from the cutters and deposits them in a mound around the hole.

The sizes of auger bits are indicated in sixteenths of an inch and are stamped on the tang (fig. 1-73). A number 10 stamped on the tang means 10/16 or 5/8 in.; number 5 means 5/16 in. and so on. The most common woodworkers auger bit set ranges in size from 1/4 to 1 in.

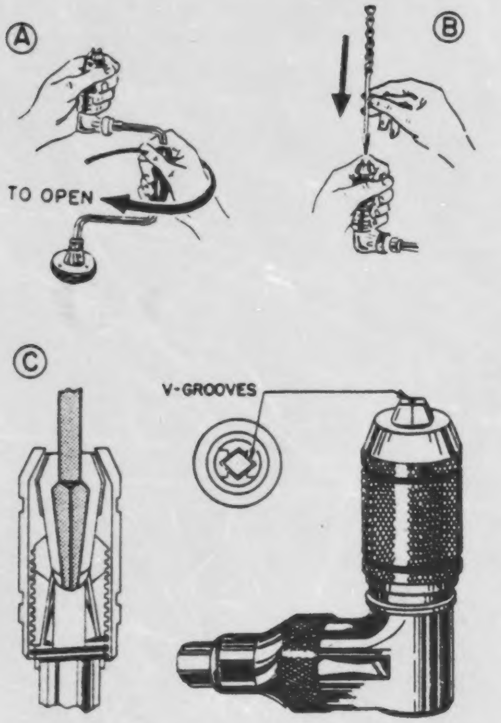
Ordinary auger bits up to 1 in. in diameter are from 7 to 9 inches long. Short auger bits that are about 3 1/2 inches long are called DOWEL bits.

EXPANSIVE auger bits have adjustable cutters, for boring holes of different diameters (fig. 1-74). Expansive bits are generally made in two different sizes. The largest size has three cutters and bores holes up to 4 inches in diameter. A scale on the cutter blade indicates the diameter of the hole to be bored.

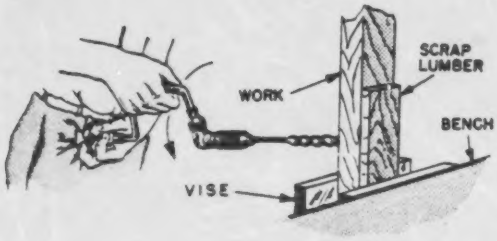
Braces and Drills

The auger bit is the tool that actually does the cutting in the wood; however, it is necessary that another tool be used to hold the auger bit and give you enough leverage to turn the bit.

657



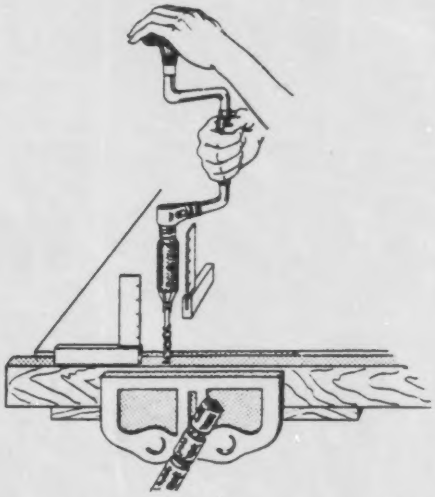
44.20G
Figure 1-76.—Placing an auger bit in a chuck.



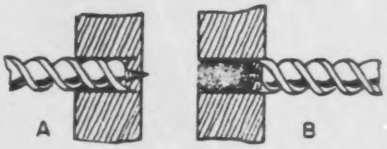
44.20H
Figure 1-77.—Using scrap lumber to prevent splintering when boring.

The tools most often used for holding the bit are the carpenter's brace, breast drill, and push drill (fig. 1-75).

BORING THROUGH HOLES IN WOOD.—To bore a hole in wood with an auger bit, first select the proper fit indicated on or near the square tang. Then you insert the auger bit into the chuck (fig. 1-76).



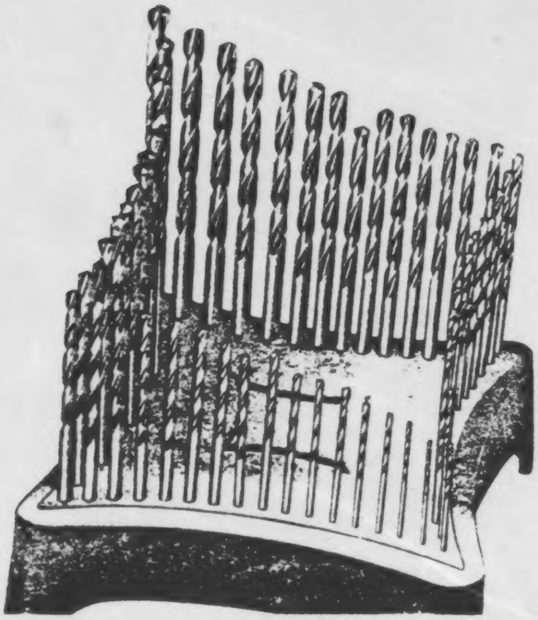
44.20K
Figure 1-78.—Method of sighting in for perpendicular hole.



44.20L
Figure 1-79.—Boring a through hole by reversing direction.

To chuck the bit, hold the shell of the chuck (fig. 1-76A), as you turn the handle to open the jaws. When the jaws are apart far enough to take the square tang of the bit, insert it (fig. 1-76B), until the end seats in the square driving socket at the bottom of the chuck. Then tighten the chuck by turning the handle to close the jaws and hold the bit in place.

With a chuck having no driving socket (a square hole which is visible if you look directly into the chuck), additional care must be taken to seat and center the corners of the tapered shank in the V grooves of the chuck jaws. (See figure 1-76C.) In this type of chuck the



44.20(4)
Figure 1-80.—Twist drills (Sizes No. 1 to No. 60).

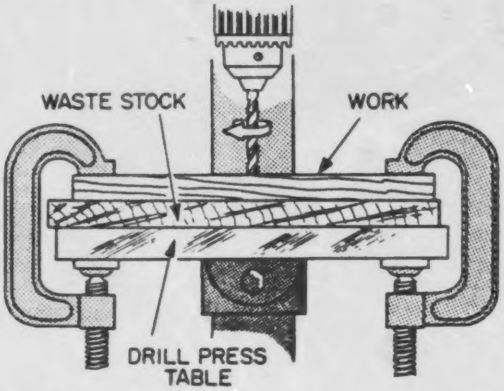
jaws serve to hold the bit in the center and to prevent it from coming out of the chuck.

After placing the point of the feed screw at the location of the center of the hole you will bore, steady the brace against your body, if possible, with the auger bit square with the surface of the work.

To bore a horizontal hole in the stock held in the bench vise, hold the head of the brace with one hand, steadying it against your body, while turning the handle with the other hand. Scrap stock behind the job will prevent splintering (fig. 1-77).

When it is not possible to make a full turn with the handle of the bit brace, turn the cam ring, shown in figure 1-75, clockwise until it stops. This will raise one of the two ratchet pawls affording clockwise ratchet action for rotating the bit. For counterclockwise ratchet action, turn the cam ring counterclockwise as far as it will go.

To bore a vertical hole in stock held in a bench vise, hold the brace and bit perpendicular to the surface of the work. Placing a trysquare near the bit, alternately in the two positions shown in figure 1-78, will help you sight it in.



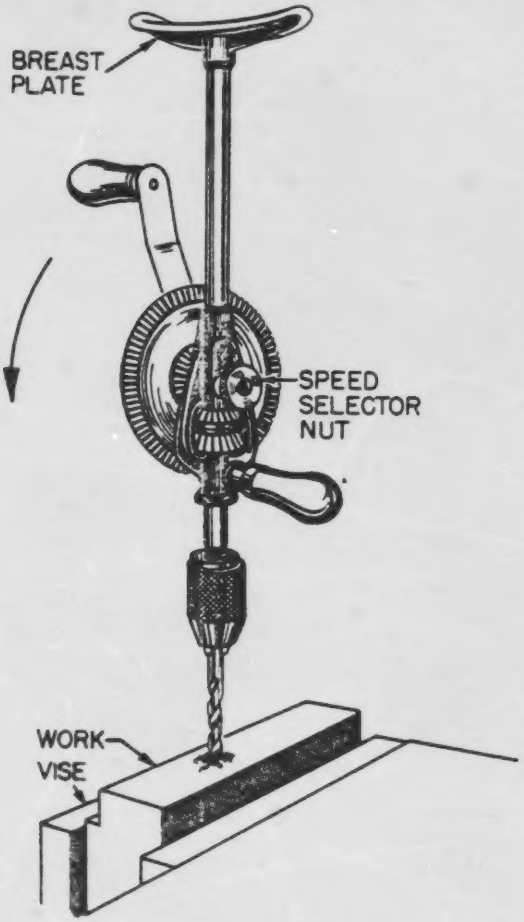
44.20R
Figure 1-81.—Drilling a hole in wood with a twist drill.

Another way to bore a through hole without splitting out on the opposite face is to reverse the bit one or two turns when the feed screw just becomes visible through this opposite face (fig. 1-79A). This will release the bit. Remove the bit while pulling it up and turning it clockwise. This will remove the loose chips from the hole. Finish the hole by boring from the opposite face. This will remove the remaining material which is usually in the form of a wooden disk held fast to the feed screw (fig. 1-79B).

DRILLING HOLES WITH A TWIST DRILL.—An ordinary twist drill may be used to drill holes in wood. Select a twist drill of the size required (fig. 1-80) and secure it in the chuck of a drill.

In figure 1-81, the twist drill has been chucked. Notice that the job is secured to the table with a pair of C-clamps. Beneath the job is a block of wood. In drilling through wood, a backup block is used to ensure a clean hole at the bottom of the job.

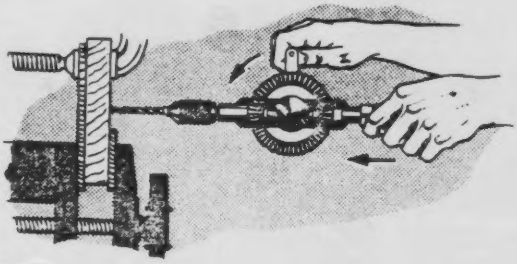
Figure 1-82 shows a hole being drilled with a breast drill. Turn the crank handle with one hand as you hold the side handle with the other hand. This will steady the breast drill while feed pressure is applied by resting your chest on the breast plate shown in figure 1-82. Notice, too, that the breast drill has a high or a low



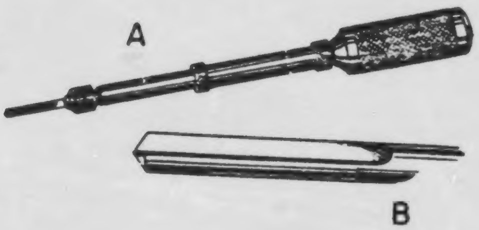
4.33A
Figure 1-82.—Drilling a hole with a breast drill.

speed available, according to the setting of the speed selector nut. When drilling a horizontal hole, apply feed pressure by resting your body against the breast plate.

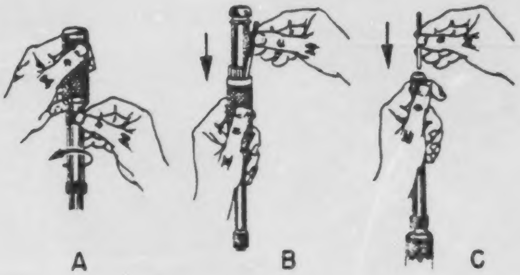
In drilling a horizontal hole with the hand drill shown in figure 1-83, operate the crank with the right hand and with the left hand guide the drill by holding the handle which is opposite the chuck end of the drill.



4.34A
Figure 1-83.—Drilling a hole with a hand drill.



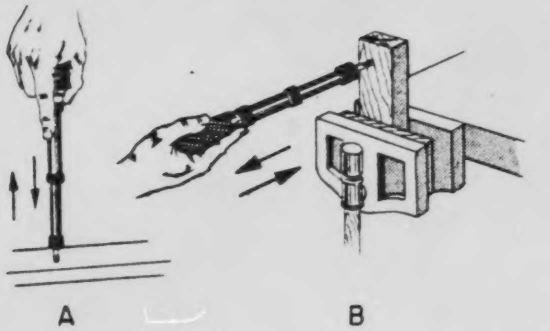
44.116
Figure 1-84.—Push drill and drill point.



44.117
Figure 1-85.—Selecting a drill for use in a push drill.

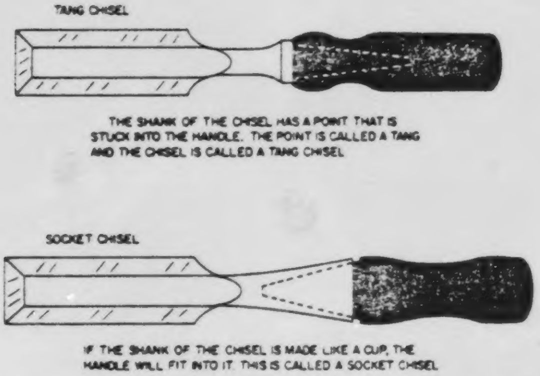
DRILLING HOLES WITH A "PUSH" DRILL.—Figure 1-84A shows the Stanley "Yankee" automatic drill which is often called a "push" drill. This drill can be used to drill either horizontal or vertical holes when the accuracy of the right angle with the work is not critical.

The drill point used in push drills (fig. 1-84B) is a straight flute drill. Sharpen its point on the grinder and provide only slight clearance behind the cutting edge. It will drill holes in wood and other soft materials.



44.118

Figure 1-86.—Drilling horizontal and vertical holes with a push drill.

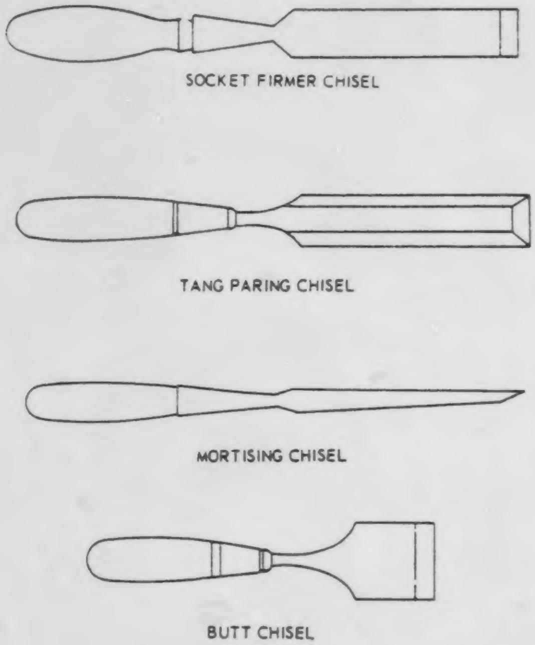


THE SHANK OF THE CHISEL HAS A POINT THAT IS STUCK INTO THE HANDLE. THE POINT IS CALLED A TANG AND THE CHISEL IS CALLED A TANG CHISEL

IF THE SHANK OF THE CHISEL IS MADE LIKE A CUP, THE HANDLE WILL FIT INTO IT. THIS IS CALLED A SOCKET CHISEL

29.9B

Figure 1-87.—Tang and socket wood chisels.



29.9C

Figure 1-88.—Shapes of common types of wood chisels.

To select a drill for use in a push drill, hold the handle of the drill in one hand and release the magazine by turning the knurled screw as shown in figure 1-85A. This will permit you to drop the magazine. Figure 1-85B, shows the drill magazine lowered to expose the drills from which the proper size can be selected.

To chuck the drill, loosen the chuck several turns and insert the drill as far as it will go. Turn the drill until it seats in the driving socket in the bottom of the chuck. Then tighten the chuck to hold the drill in place. (fig. 1-85C).

To drill a vertical hole with this drill (fig. 1-86A), place the job on a flat surface and operate the push drill with alternate strokes up and down. If it is necessary to hold the work in place while it is being drilled, use some mechanical means if you can. If you must hold the job with your hand, grasp the material as far as possible from where the drill is drilling.

In drilling horizontal holes with the push drill, as in figure 1-86B, secure the job in a vise. The back-and-forth strokes rotate the drill, advancing it into the work on the forward stroke as the drilling proceeds. The index finger, extended along the body of the tool, will help guide the drilling at right angles to the work.

WOOD CHISELS

A wood chisel is a steel tool fitted with a wooden or plastic handle. It has a single beveled cutting edge on the end of the steel part, or blade. According to their construction, chisels may be divided into two general classes: TANG chisels, in which part of the chisel enters the handle, and SOCKET chisels, in which the handle enters into a part of the chisel (fig. 1-87).

A socket chisel is designed for striking with a wooden mallet (never a steel hammer), while a tang chisel is designed for hand manipulation only.

Wood chisels are also divided into types, depending upon their weights and thicknesses, the shape or design of the blade, and the work they are intended to do.

The shapes of the more common types of wood chisels are shown in figure 1-88. The FIRMER chisel has a strong, rectangular-cross-section blade, designed for both heavy and light work. The blade of the PARING chisel is relatively thin, and is beveled along the sides for the fine paring work. The BUTT chisel has a short blade, designed for work in hard-to-get-at places.

The butt chisel is commonly used for chiseling the GAINS (rectangular depressions) for the BUTT hinges on doors; hence the name. The MORTISING chisel is similar to a socket firmer but has a narrow blade, designed for chiseling out the deep, narrow MORTISES for mortise-and-tenon joints. This work requires a good deal of levering out of chips; consequently, the mortising chisel is made extra thick in the shaft to prevent breaking.

A FRAMING chisel is shaped like a firmer chisel, but has a very heavy, strong blade designed for work in rough carpentry.

A wood chisel should always be held with the flat side or back of the chisel against the work for smoothing and finishing cuts. Whenever possible, it should not be pushed straight through an opening, but should be moved laterally at the same time that it is pushed forward. This method ensures a shearing cut, which with care, will produce a smooth and even surface even when the work is cross-grained. On rough work, use a hammer or mallet to drive the socket-type chisel.

On fine work, use your hand as the driving power on tang-type chisels. For rough cuts, the bevel edge of the chisel is held against the work. Whenever possible, other tools such as saws and planes should be used to remove as much of the waste as possible, and the chisel used for finishing purposes only.

These are a few basic precautions that you should observe at all times when using a chisel.

a. Secure work so that it cannot move.

b. Keep both hands back of the cutting edge at all times.

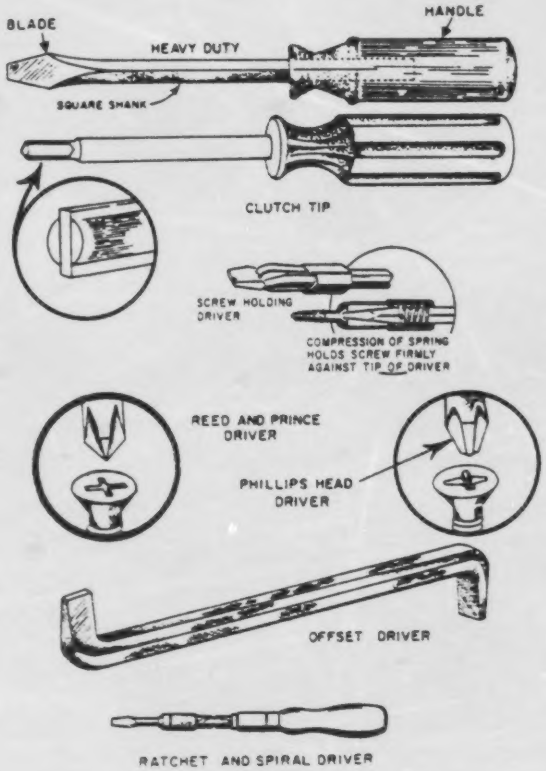
c. Do not start a cut on a guideline. Start slightly away from it, so that there is a small amount of material to be removed by the finishing cuts.

d. When starting a cut, always chisel away from the guideline toward the waste wood, so that no splitting will occur at the edge.

e. Never cut towards yourself with a chisel.

f. Make the shavings thin, especially when finishing.

g. Examine the grain of the wood to see which way it runs. Cut with the grain. This severs the fibers and leaves the wood smooth. Cutting against the grain splits the wood and leaves it rough. This type of cut cannot be controlled.



1.14(44B)A

Figure 1-89.—Screwdrivers.

SCREWDRIVERS

A screwdriver is one of the most basic of basic handtools. It is also the most frequently abused of all handtools. It is designed for one function only—to drive and remove screws. A screwdriver should not be used as a pry bar, a scraper, a chisel, or a punch.

STANDARD

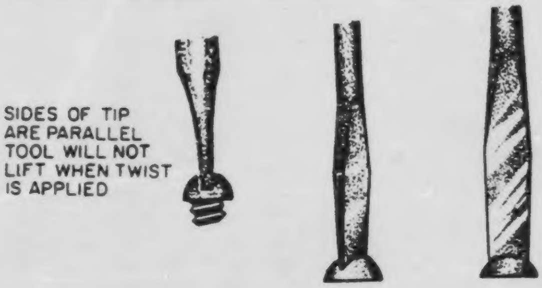
There are three main parts to a standard screwdriver. The portion you grip is called the handle, the steel portion extending from the handle is the shank, and the end which fits into the screw is called the blade (fig. 1-89).

The steel shank is designed to withstand considerable twisting force in proportion to its size, and the tip of the blade is hardened to keep it from wearing.

Standard screwdrivers are classified by size, according to the combined length of the shank and blade. The most common sizes range in length from 2 1/2 in. to 12 in. There are many screwdrivers smaller and some larger for special purposes. The diameter of the shank, and the width and thickness of the blade are generally proportionate to the length, but again there are special screwdrivers with long thin shanks, short thick shanks, and extra wide or extra narrow blades.

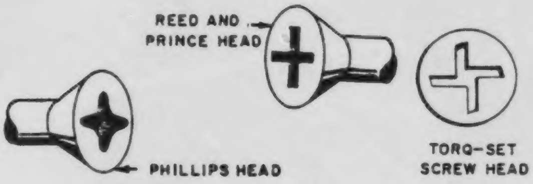
Screwdriver handles may be wood, plastic, or metal. When metal handles are used, there is usually a wooden hand grip placed on each side of the handle. In some types of wood- or plastic-handled screwdrivers the shank extends through the handle, while in others the shank enters the handle only a short way and is pinned to the handle. For heavy work, special types of screwdrivers are made with a square shank. They are designed this way so that they may be gripped with a wrench, but this is the only kind on which a wrench should be used.

When using a screwdriver it is important to select the proper size so that the blade fits the screw slot properly. This prevents burring the slot and reduces the force required to hold the driver in the slot. Keep the shank perpendicular to the screw head (fig. 1-90).



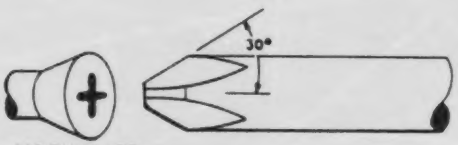
1.14(44B)B

Figure 1-90.—Positioning screwdrivers.

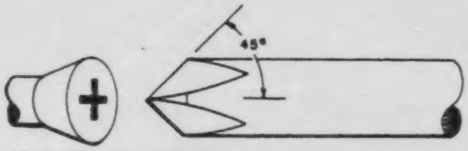


29.123(44B)

Figure 1-91.—Comparison of Phillips, Reed, and Prince and Torq-Set screwheads.



(A) PHILLIPS



(B) REED AND PRINCE

1.14(44B)C

Figure 1-92.—Matching cross-slot screws and drivers.

RECESSED

Recessed screws are now available in various shapes. They have a cavity formed in the head and require a specially shaped screwdriver. The clutch tip (fig. 1-89) is one shape, but the more common include the Phillips, Reed and Prince, and newer Torq-Set types (fig. 1-91). The most common type found is the

Phillips head screw. This requires a Phillips-type screwdriver (fig. 1-89).

Phillips Screwdriver

The head of a Phillips-type screw has a four-way slot into which the screwdriver fits. This prevents the screwdriver from slipping. Three standard sized Phillips screwdrivers handle a wide range of screw sizes. Their ability to hold helps to prevent damaging the slots or the work surrounding the screw. It is a poor practice to try to use a standard screwdriver on a Phillips screw because both the tool and screw slot will be damaged.

Reed and Prince Screwdriver

Reed and Prince screwdrivers are not interchangeable with Phillips screwdrivers. Therefore, always use a Reed and Prince screwdriver with Reed and Prince screws and a Phillips screwdriver with Phillips screws, or a ruined tool or ruined screwhead will result.

How do you distinguish between these similar screwdrivers? Refer to figure 1-92.

The Phillips screwdriver has about 30-degree flukes and a blunt end, while the Reed and Prince has 45-degree flukes and a sharper, pointed end. The Phillips screw has beveled walls between the slots; the Reed and Prince, straight, pointed walls. In addition, the Phillips screw slot is not as deep as the Reed and Prince slot.

Additional ways to identify the right screwdriver are as follows:

1. If it tends to stand up unassisted when the point is put in the head of a vertical screw, it is probably the proper one.
2. The outline of the end of a Reed and Prince screwdriver is approximately a right angle, as seen in the illustration.
3. In general, Reed and Prince screws are used for airframe structural applications, while Phillips screws are found most often in component assemblies.

"Torq-Set" Screws

"Torq-Set" machine screws (offset cross-slot drive) have recently begun to appear in new equipment. The main advantage of the newer type is that more torque can be applied to its head while tightening or loosening than any other screw of comparable size and material without damaging the head of the screw.

Torq-Set machine screws are similar in appearance to the more familiar Phillips machine screws.

Since a Phillips driver could easily damage a Torq-Set screwhead, making it difficult if not impossible to remove the screw even if the proper tool is later used, maintenance personnel should be alert to the differences (fig. 1-91) and ensure that the proper tool is used.

OFFSET SCREWDRIVERS.—An offset screwdriver (fig. 1-89) may be used where there is not sufficient vertical space for a standard or recessed screwdriver. Offset screwdrivers are constructed with one blade forged in line and another blade forged at right angles to the shank handle. Both blades are bent 90 degrees to the shank handle. By alternating ends, most screws can be seated or loosened even when the swinging space is very restricted. Offset screwdrivers are made for both standard and recessed head screws.

RATCHET SCREWDRIVER

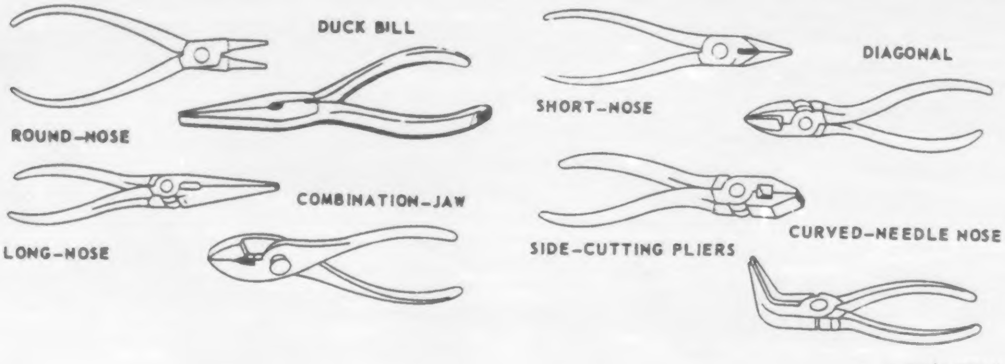
For fast easy work the ratchet screwdriver (fig. 1-89), is extremely convenient, as it can be used one-handed and does not require the bit to be lifted out of the slot after each turn. It may be fitted with either a standard type bit or a special bit for recessed heads. The ratchet screwdriver is most commonly used by the woodworker for driving screws in soft wood.

SAFETY

- Never use a screwdriver to check an electrical circuit.
- Never try to turn a screwdriver with a pair of pliers.
- Do not hold work in your hand while using a screwdriver—if the point slips it can cause a bad cut. Hold the work in a vise, with a clamp, or on a solid surface. If that is impossible, you will always be safe if you follow this rule: NEVER GET ANY PART OF YOUR BODY IN FRONT OF THE SCREWDRIVER BLADE TIP. That is a good safety rule for any sharp or pointed tool.

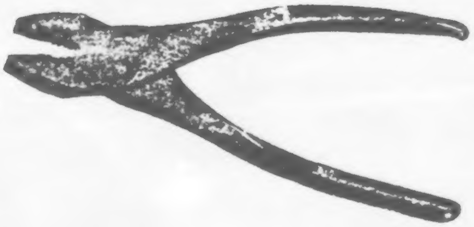
PLIERS

Pliers are made in many styles and sizes and are used to perform many different



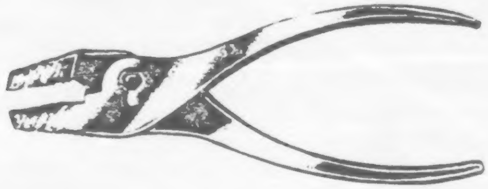
1.21(44B)A

Figure 1-93.—Pliers.



1.21.4A

Figure 1-94.—Slipjoint pliers.



1.21.4B

Figure 1-95.—Slipjoint combination pliers.

operations. Pliers are used for cutting purposes as well as holding and gripping small articles in situations where it may be inconvenient or impossible to use hands. Figure 1-93 shows several different kinds.

The combination pliers are handy for holding or bending flat or round stock. The long-nosed pliers are less rugged, and break easily if you use them on heavy jobs. Long-nosed pliers commonly called needle-nose pliers are especially useful for holding small objects in tight places and for making delicate adjustments. The round-nosed kind are handy when you need to crimp sheet metal or form a loop in a wire, The diagonal cutting pliers, commonly called "diagonals" or "dikes," are designed for cutting wire and cotter pins close to a flat surface and are especially useful in the electronic and electrical fields. The duckbill pliers are used extensively in aviation areas.

Here are two important rules for using pliers:

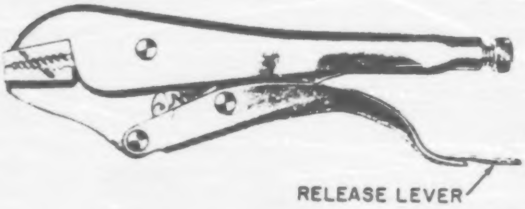
1. Do not make pliers work beyond their capacity. The long-nosed kind are especially delicate. It is easy to spring or break them, or nick their edges. After that, they are practically useless.

2. Do not use pliers to turn nuts. In just a few seconds, a pair of pliers can damage a nut. Pliers must not be substituted for wrenches.

SLIP-JOINT PLIERS

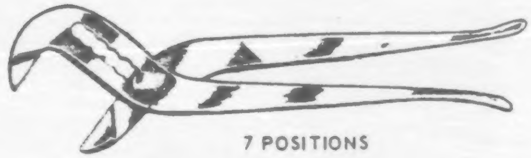
Slip-joint pliers (fig. 1-94) are pliers with straight, serrated (grooved) jaws, and the screw or pivot with which the jaws are fastened together may be moved to either of two positions, in order to grasp small- or large-sized objects better.

To spread the jaws of slip-joint pliers, first spread the ends of the handles apart as far as possible. The slip-joint, or pivot, will now move to the open position. To close, again spread the handles as far as possible, then push the joint back into the closed position.



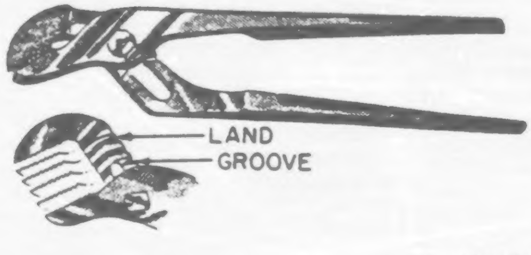
1.21D

Figure 1-96.—Vise grip pliers.



44.22

Figure 1-97.—Water pump pliers.



1.21(44B)B

Figure 1-98.—Channel-lock pliers.

Slip-joint combination pliers (fig. 1-95) are pliers similar to the slip-joint pliers just described, but with the additional feature of a side cutter at the junction of the jaws. This cutter consists of a pair of square cut notches, one on each jaw, which act like a pair of shears when an object is placed between them and the jaws are closed.

The cutter is designed to cut material such as soft wire and nails. To use the cutter, open the jaws until the cutter on either jaw lines up with the other. Place the material to be cut as far back as possible into the opening formed by the cutter, and squeeze the handles of the pliers together. Do not attempt to cut hard material such as spring wire or hard rivets with the combination pliers. To do so will spring the jaws; and if the jaws are sprung, it will be difficult thereafter to cut small wire with the cutters.

WRENCH (VISE-GRIP) PLIERS

Vise-grip pliers (fig. 1-96), can be used for holding objects regardless of their shape. A screw adjustment in one of the handles makes them suitable for several different sizes. The jaws of vise-grips may have standard serrations such as the pliers just described or may have a clamp-type jaw. The clamp-type jaws are generally wide and smooth and are used primarily when working with sheet metal.

Vise-grip pliers have an advantage over other types of pliers in that you can clamp them on an object and they will stay. This will leave your hands free for other work.

A craftsman uses this tool a number of ways. It may be used as a clamp, speed wrench, portable vise, and for many other uses where a locking, plier type jaw may be employed. These pliers can be adjusted to various jaw openings by turning the knurled adjusting screw at the end of the handle (fig. 1-96). Vise-grips can be clamped and locked in position by pulling the lever toward the handle.

CAUTION: Vise-grip pliers should be used with care since the teeth in the jaws tend to damage the object on which they are clamped. They should not be used on nuts, bolts, tube fittings, or other objects which must be reused.

WATER-PUMP PLIERS

Water-pump pliers were originally designed for tightening or removing water pump packing nuts. They were excellent for this job because they have a jaw adjustable to seven different positions. Water-pump pliers (fig. 1-97) are easily identified by their size, jaw teeth, and adjustable slip joint. The inner surface of the jaws consists of a series of coarse teeth formed by deep grooves, a surface adapted to grasping cylindrical objects.

CHANNEL-LOCK PLIERS

Channel-lock pliers (fig. 1-98) are another version of water-pump pliers easily identified by the extra long handles, which make them a very powerful gripping tool. They are shaped approximately the same as the pliers just described, but the jaw opening adjustment is

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effected differently. Channel-lock pliers have grooves on one jaw and lands on the other. The adjustment is effected by changing the position of the grooves and lands. The Channel-lock pliers are less likely to slip from the adjustment setting when gripping an object. The channel-lock pliers will only be used where it is impossible to use a more adapted wrench or holding device. Many nuts and bolts and surrounding parts have been damaged by improper use of channel-lock pliers.

DIAGONAL PLIERS

Diagonal cutting pliers (fig. 1-93) are used for cutting small, light material, such as wire and cotter pins in areas which are inaccessible to the larger cutting tools. Also, since they are designed for cutting only, larger objects can be cut than with the slip-joint pliers.

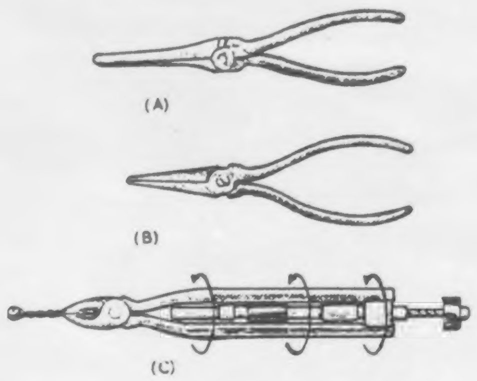
As the cutting edges are diagonally offset approximately 15 degrees, diagonal pliers are adapted to cutting small objects flush with a surface. The inner jaw surface is a diagonal straight cutting edge. Diagonal pliers should never be used to hold objects, because they exert a greater shearing force than other types of pliers of a similar size. The sizes of the diagonal cutting pliers are designated by the overall length of the pliers.

SIDE-CUTTING PLIERS

Side-cutting pliers (sidecutters) are principally used for holding, bending, and cutting thin materials or small gage wire. Sidecutters vary in size and are designated by their overall length. The jaws are hollowed out on one side just forward of the pivot point of the pliers. Opposite the hollowed out portion of the jaws are the cutting edges (fig. 1-93).

When holding or bending light metal surfaces, the jaw tips are used to grasp the object. When holding wire grasp it as near one end as possible because the jaws will mar the wire. To cut small diameter wire the side cutting edge of the jaws near the pivot is used. Never use sidecutters to grasp large objects, tighten nuts, or bend heavy gage metal, since such operations will spring the jaws.

Sidecutters are often called electrician or lineman pliers. They are used extensively for stripping insulation from wire and for twisting wire when making a splice.



1.21(44B)C

Figure 1-99.—Pliers. (A) Duckbill; (B) needle nose; and (C) wire twister.

DUCKBILL PLIERS

Duckbill pliers (fig. 1-99A), have long wide jaws and slender handles. Duckbills are used in confined areas where the fingers cannot be used. The jaw faces of the pliers are scored to aid in holding an item securely. Duckbills are ideal for twisting the safety wire used in securing nuts, bolts, and screws.

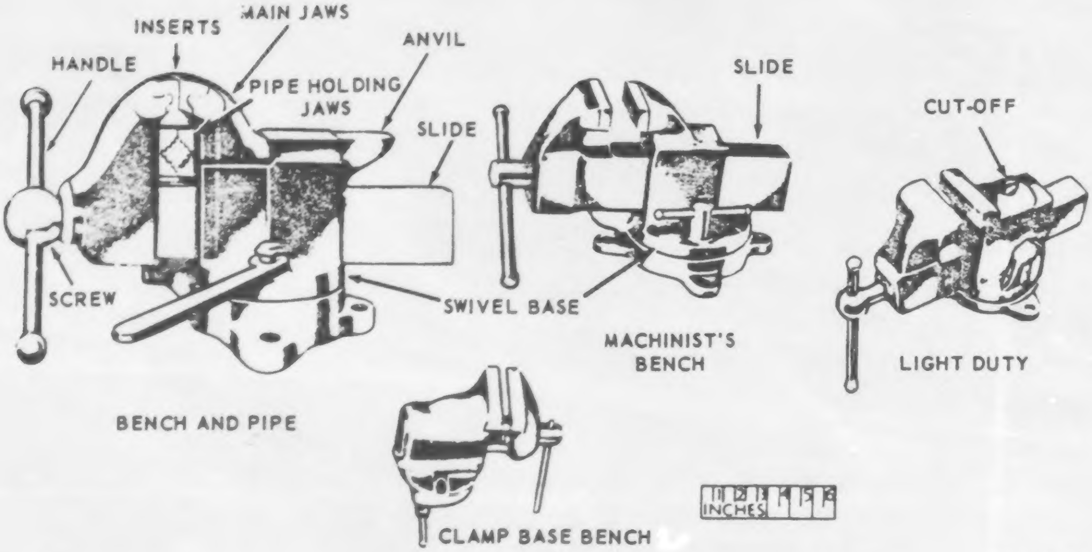
NEEDLE-NOSE PLIERS

Needle-nose pliers (fig. 1-99B), are used in the same manner as duckbill pliers. However, there is a difference in the design of the jaws. Needle-nose jaws are tapered to a point which makes them adapted to installing and removing small cotter pins. They have serrations at the nose end and a side cutter near the throat. Needle-nose pliers may be used to hold small items steady, to cut and bend safety wire, or to do numerous other jobs which are too intricate or too difficult to be done by hand alone.

NOTE: Duckbill and needle-nose pliers are especially delicate. Care should be exercised when using these pliers to prevent springing, breaking, or chipping the jaws. Once these pliers are damaged, they are practically useless.

WIRE-TWISTER PLIERS

Wire-twister pliers (fig. 1-99C), are three-way pliers, which hold, twist, and cut. They



11.3(44)

Figure 1-100.—Common types of bench vises.

are designed to reduce the time used in twisting safety wire on nuts and bolts. To operate, grasp the wire between the two diagonal jaws, and the thumb will bring the locking sleeve into place. A pull on the knob twirls the twister, making uniform twists in the wire. The spiral rod may be pushed back into the twister without unlocking it, and another pull on the knob will give a tighter twist to the wire. A squeeze on the handle unlocks the twister, and the wire can be cut to the desired length with the side cutter. The spiral of the twister should be lubricated occasionally.

MAINTENANCE OF PLIERS

Nearly all sidecutting pliers and diagonals are designed so that the cutting edges can be reground. Some older models of pliers will not close if material is ground from the cutting edges. When grinding the cutting edges never take any more material from the jaws than is necessary to remove the nicks. Grind the same amount of stock from both jaws.

NOTE: When jaws on pliers do not open enough to permit grinding, remove the pin that attaches the two halves of the pliers so that the jaws can be separated.

The serrations on the jaws of pliers must be sharp. When they become dull, the pliers should be held in a vise and the serrations recut by using a small 3-corner file.

Pliers should be coated with light oil when they are not in use. They should be stored in a toolbox in such a manner that the jaws cannot be injured by striking hard objects. Keep the pin or bolt at the hinge just tight enough to hold the two parts of the pliers in contact and always keep the pivot pin lubricated with a few drops of light oil.

VISES AND CLAMPS

Vises are used for holding work when it is being planed, sawed, drilled, shaped, sharpened, or riveted, or when wood is being glued. Clamps are used for holding work which cannot be satisfactorily held in a vise because of its shape and size, or when a vise is not available. Clamps are generally used for light work.

Figure 1-100 shows the most common bench vises that are used throughout the Navy.

A MACHINIST'S BENCH VISE is a large steel vise with rough jaws that prevent the work from slipping. Most of these vises have a swivel base with jaws that can be rotated, while others cannot be rotated. A similar light duty model is equipped with a cutoff. These vises are usually bolt-mounted onto a bench.

THE BENCH AND PIPE VISE has integral pipe jaws for holding pipe from 3/4 inch to 3 inches in diameter. The maximum working main jaw opening is usually 5 inches, with a jaw width of 4 to 5 inches. The base can be swiveled to any position and locked. These vises are equipped with an anvil and are also bolted onto a workbench.

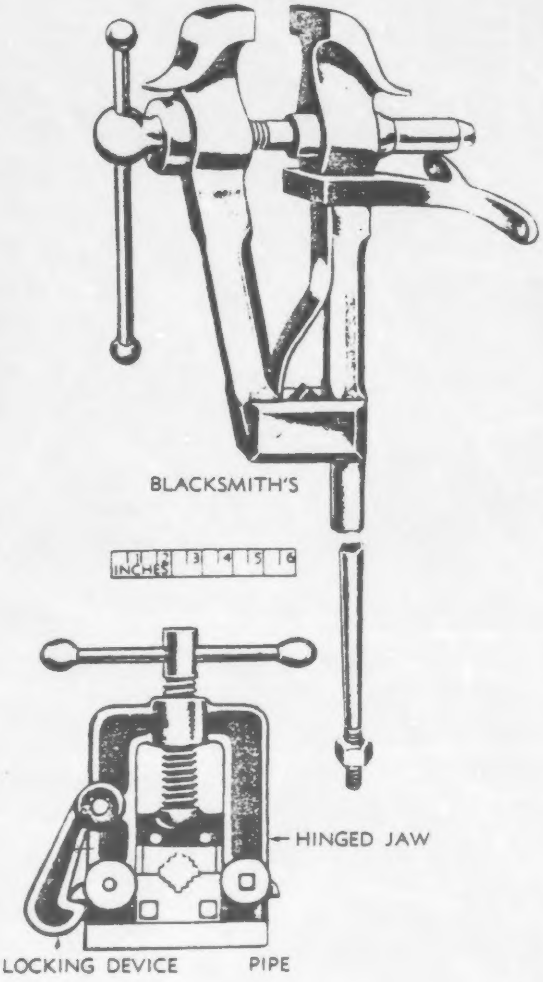
The CLAMP BASE VISE usually has a smaller holding capacity than the machinist's or the bench and pipe vise and is usually clamped to the edge of a bench with a thumbscrew. These type vises can be obtained with a maximum holding capacity varying between 1 1/2 in. and 3 in. These vises normally do not have pipe holding jaws.

The BLACKSMITH'S VISE (fig. 1-101) is used for holding work that must be pounded with a heavy hammer. It is fastened to a sturdy workbench or wall, and the long leg is secured into a solid base on the floor.

The PIPE VISE (fig. 1-101) is specifically designed to hold round stock or pipe. The vise shown has a capacity of 1 to 3 inches. One jaw is hinged so that the work can be positioned and then the jaw brought down and locked. This vise is also used on a bench. Some pipe vises are designed to use a section of chain to hold down the work. Chain pipe vises range in size from 1/8- to 2 1/2 inch pipe capacity up to 1/2- to 8-inch pipe capacity.

A C-CLAMP (fig. 1-102) is shaped like the letter C. It consists of a steel frame threaded to receive an operating screw with a swivel head. It is made for light, medium, and heavy service in a variety of sizes.

A HAND SCREW CLAMP (fig. 1-102) consists of two hard maple jaws connected with two operating screws. Each jaw has two metal inserts into which the screws are threaded. The hand screw clamp is also issued from supply in a variety of sizes.



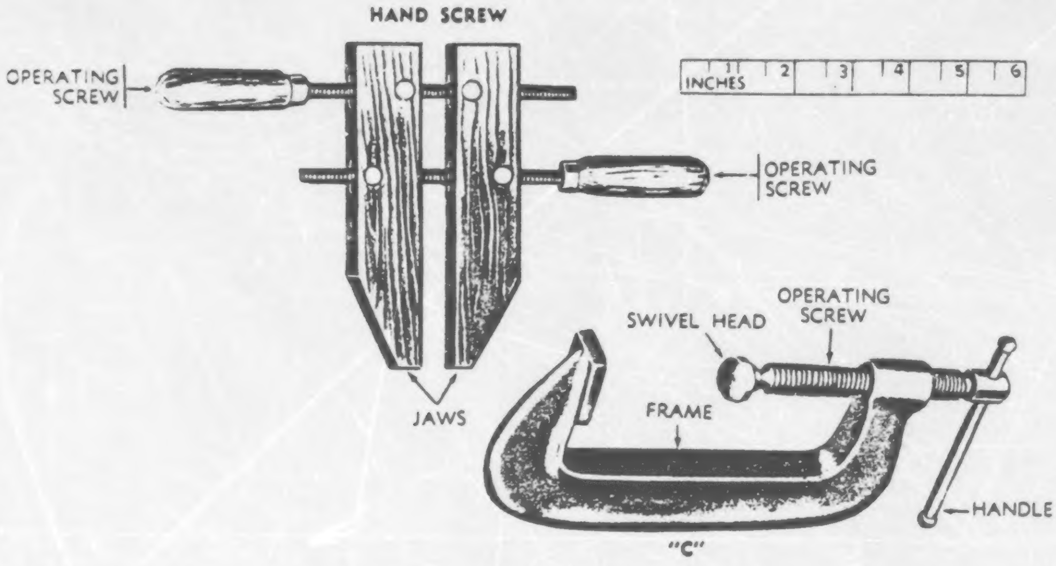
11.3B

Figure 1-101.—Blacksmith's and pipe vises.

CARE

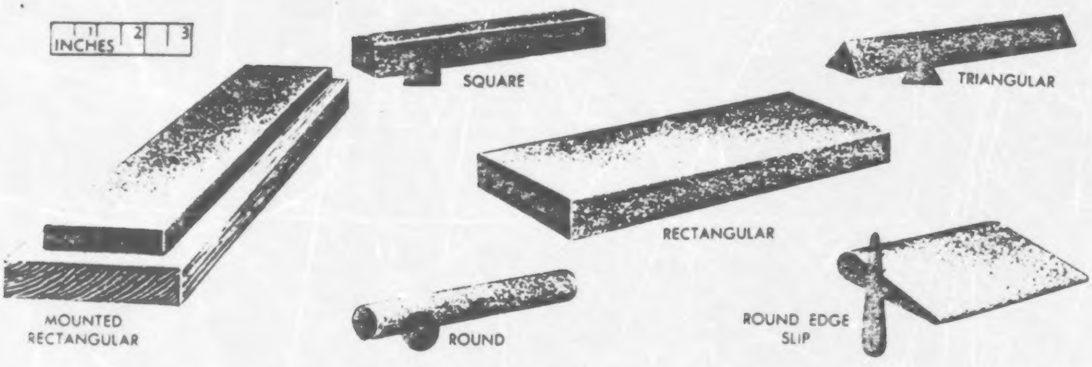
Keep vises clean at all times. They should be cleaned and wiped with light oil after using. Never strike a vise with a heavy object and never hold large work in a small vise, since these practices will cause the jaws to become sprung or otherwise damage the vise. Keep jaws in good condition and oil the screws and the slide frequently. Never oil the swivel base of swivel jaw joint; its holding power will be impaired. When the vise is not in use, bring the jaws lightly together or leave a very small gap. (The movable jaw of a tightly closed vise may break due to the expansion of the metal in heat.) Leave the handle in a vertical position.

Threads of C-clamps must be clean and free from rust. The swivel head must also be clean, smooth, and grit free. If the swivel head becomes damaged, replace it as follows: pry


HAND SCREW
OPERATING SCREW
INCHES 1 2 3 4 5 6
OPERATING SCREW
JAWS
SWIVEL HEAD
OPERATING SCREW
FRAME
HANDLE
"C"

29.11A

Figure 1-102.—C-Clamp and handscrew clamp.


INCHES 1 2 3
SQUARE
TRIANGULAR
RECTANGULAR
MOUNTED RECTANGULAR
ROUND
ROUND EDGE SLIP

44.35

Figure 1-103.—Shapes of sharpening stones and oilstones.

open the crimped portion of the head and remove the head from the ball end of the screw. Replace with a new head and crimp.

SAFETY PRECAUTIONS

When closing the jaw of a vise or clamp, avoid getting any portion of your hands or body between the jaws or between one jaw and the work.

When holding heavy work in a vise, place a block of wood under the work as a prop to prevent it from sliding down and falling on your foot.

Do not open the jaws of a vise beyond their capacity, as the movable jaw will drop off, causing personal injury and possible damage to the jaw.

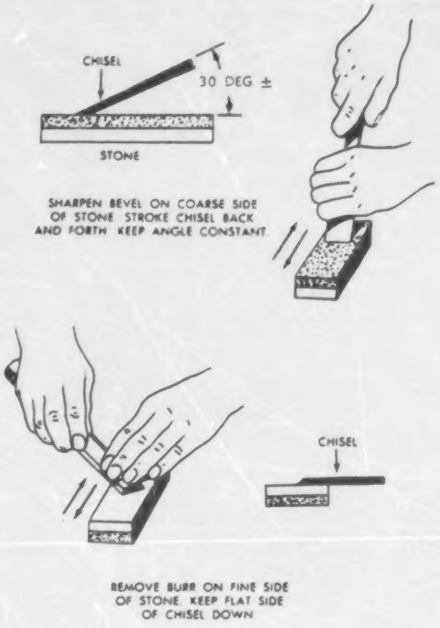
SHARPENING STONES

Sharpening stones are divided into two groups, natural and artificial. Some of the natural stones are oil treated during and after the manufacturing processes. The stones that are oil treated are sometimes called oilstones. Artificial stones are normally made of silicone carbide or aluminum oxide. Natural stones have very fine grains and are excellent for putting razorlike edges on fine cutting tools. Most sharpening stones have one coarse and one fine face. Some of these stones are mounted, and the working face of some of the sharpening stones is a combination of coarse and fine grains. Stones are available in a vareity of shapes, as shown in figure 1-103.

A fine cutting oil is generally used with most artificial sharpening stones; however, other lubricants such as kerosene may be used. When a tool has been sharpened on a grinder or grindstone, there is usually a wire edge or a feather edge left by the coarse wheel. The sharpening stones are used to hone this wire or feather edge off the cutting edge of the tool. Do not attempt to do a honing job with the wrong stone. Use a coarse stone to sharpen large and very dull or nicked tools. Use a medium grain stone to sharpen tools not requiring a finished edge, such as tools for working soft wood, cloth, leather, and rubber. Use a fine stone and an oilstone to sharpen and hone tools requiring a razorlike edge.

Prevent glazing of sharpening stones by applying a light oil during the use of the stone. Wipe the stone clean with wiping cloth or cotton waste after each use. If stone becomes glazed or gummed up, clean with aqueous ammonia or drycleaning solvent. If necessary, scour with aluminum oxide abrasive cloth or flint paper attached to a flat block.

At times, stones will become uneven from improper use. True the uneven surfaces on an old grinding wheel or on a grindstone. Another method of truing the surface is to lap it with a block of cast iron or other hard material covered with a waterproof abrasive paper, dipping the stone in water at regular intervals and continuing the lapping until the stone is true.


CHISEL
30 DEG ±
STONE
SHARPEN BEVEL ON COARSE SIDE OF STONE. STROKE CHISEL BACK AND FORTH. KEEP ANGLE CONSTANT
CHISEL
REMOVE BURR ON FINE SIDE OF STONE. KEEP FLAT SIDE OF CHISEL DOWN

29.9N

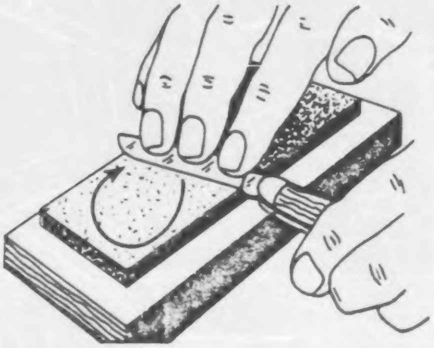
Figure 1-104.—Sharpening a woodworker's chisel.

Stones must be carefully stored in boxes or on special racks when not in use. Never lay them down on uneven surfaces or place them where they may be knocked off a table or bench, or where heavy objects can fall on them. Do not store in a hot place.

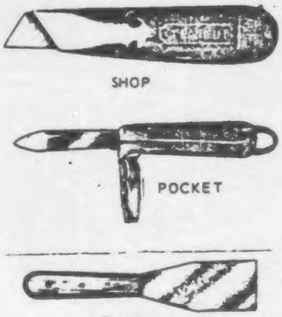
SHARPENING A WOOD CHISEL

To sharpen a wood chisel with a sharpening stone, use a common oilstone that has coarse grit on one side and fine grit on the other (fig. 1-104). Make sure the stone is firmly held so that it cannot move. Cover the stone with a light machine oil so that the fine particles of steel ground off will float and thus prevent the stone from clogging.

Hold the chisel in one hand with the bevel flat against the coarse side of the stone. Use the fingers of your other hand to steady the chisel and hold it down against the stone. Using smooth even strokes, rub the chisel back and forth parallel to the surface of the stone (fig. 5-18). The entire surface of the stone should be used to avoid wearing a hollow in the center of the stone. Do not rock the blade. The angle of the



44.137
Figure 1-105.—Sharpening a pocket knife.



44.210
Figure 1-106.—Knives.

blade with the stone must remain constant during the whetting process.

After a few strokes, a burr, wire edge, or feather edge is produced. To remove the burr, first take a few strokes with the flat side of the chisel held flat on the fine grit side of the stone. Be careful not to raise the chisel even slightly; avoid putting the slightest bevel on the flat side, for then the chisel must be ground until the bevel is removed.

After whetting the flat side on the fine grit side of the stone, turn the chisel over and place the bevel side down and hold it at the same angle as used when whetting on the coarse side of the stone. Take two or three light strokes to remove the burr.

To test the sharpness of the cutting edge, hold the chisel where a good light will shine on the cutting edge. A keen edge does not reflect light in any position. If there are no shiny or white spots it is a good edge.

SHARPENING A POCKET KNIFE

Pocket knives may be sharpened on a medium or fine grade sharpening stone with a few drops of oil spread on the surface. Hold the handle of the knife in one hand and place the blade across the stone. Press down with the fingers of the other hand and stroke the blade following a circular motion as shown in figure 1-105. After several strokes, reverse the blade and stroke the opposite side, following the same type of motion. Use a light even pressure. A thin blade overheats quickly and can lose its temper. The wire edge or burr that may be left on a knife blade after whetting may be removed by stropping both sides on a soft wood block, canvas or leather.

MISCELLANEOUS TOOLS

Tools described in this section may be encountered at some time in your Navy career. They may not necessarily be found in any particular toolkit but may be stored in a central toolroom, to be checked out when needed. This section of the text will give you some tips on their nomenclature, where and how they can be used, and some safety precautions to be observed when using these tools.

KNIVES

Most knives are used to cut, pare, and trim wood, leather, rubber and other similar materials. The types you will probably encounter most frequently are the shop knife, pocket knife, and the putty knife (fig. 1-106).

The shop knife can be used to cut cardboard, linoleum, and paper. It has an aluminum handle and is furnished with interchangeable blades stored in the 5-inch handle.

Pocket knives are used for light cutting, sharpening pencils, cutting strings, etc. They are unsuited for heavy work. Multi-purpose knives have an assortment of blades designed for forcing holes, driving screws and opening cans, as well as cutting. The blades are hinged and should be contained within the case when not in use. They are spring loaded to keep them firmly in place when open or closed.

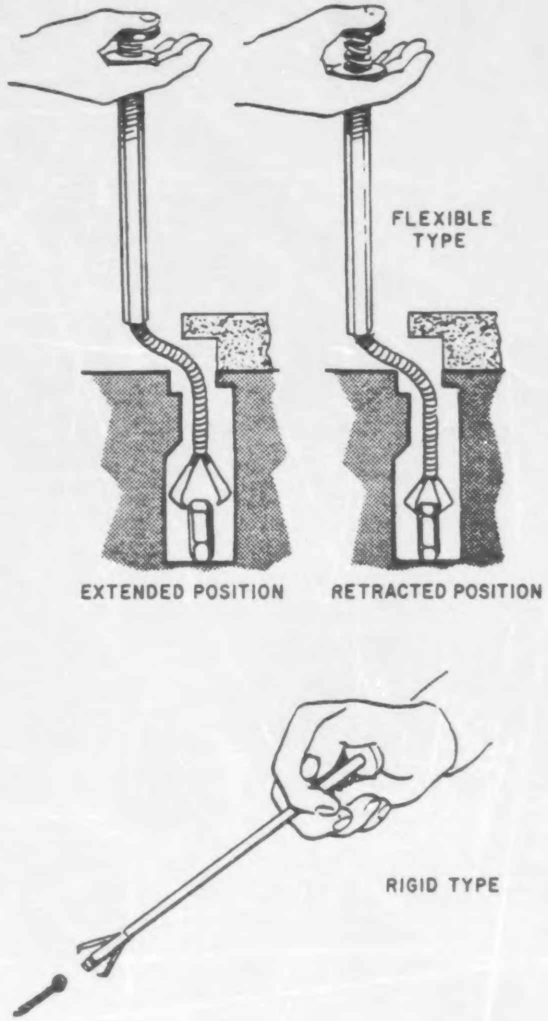
A putty knife is used for applying putty to window sash when setting in panes of glass. The blade has a wide square point available in different lengths and widths.

Safety with knives is essential. Do not use knives larger than can be safely handled. Use knives only for the purpose for which they were designed. Always cut away from your body. Do not carry open knives in your pocket or leave them where they may come into contact with or cause injury to others. Put knives away carefully after use to protect sharp cutting edges from contacting other hard objects.

MECHANICAL FINGERS

Small articles which have fallen into places where they cannot be reached by hand may be retrieved with the mechanical fingers. This tool is also used when starting nuts or bolts in difficult areas. The mechanical fingers, shown in figure 1-107 have a tube containing flat springs which extend from the end of the tube to form clawlike fingers, much like the screw holder. The springs are attached to a rod that extends from the outer end of the tube. A plate is attached to the end of the tube, and a similar plate to be pressed by the thumb is attached to the end of the rod. A coil spring placed around the rod between the two plates holds them apart and retracts the fingers into the tube. With the bottom plate grasped between the fingers and enough thumb pressure applied to the top plate to compress the spring, the tool fingers extend from the tube in a grasping position. When the thumb pressure is released, the tool fingers retract into the tube as far as the object they hold will allow. Thus, enough pressure is applied on the object to hold it securely. Some mechanical fingers have a flexible end on the tube to permit their use in close quarters or around obstructions (fig. 1-107).

NOTE: Mechanical fingers should not be used as a substitute for wrenches or pliers. The fingers are made of thin sheet metal or spring wire and can be easily damaged by overloading.

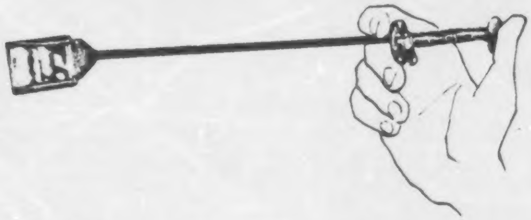


44.211

Figure 1-107.—Mechanical fingers.

Flashlight

Each toolbox should have a standard Navy vaporproof two-cell flashlight. The flashlight is used constantly during all phases of maintenance. Installed in both ends of the flashlight are rubber seals which keep out all vapors. The flashlight should be inspected periodically for the installation of these seals, the spare bulb, and colored filters which are contained in the end cap. NOTE: Do not throw away the filters; they will be necessary during night operations.



44.212

Figure 1-108.—Adjustable inspection mirror.

INSPECTION MIRROR

There are several types of inspection mirrors available for use in maintenance. The mirror is issued in a variety of sizes and may be round or rectangular. The mirror is connected to the end of a rod and may be fixed or adjustable (fig. 1-108).

The inspection mirror aids in making detailed inspection where the human eye cannot directly see the inspection area. By angling the mirror, and with the aid of a flashlight, it is possible to inspect most required areas. A late model inspection mirror features a built-in light to aid in viewing those dark places where use of a flashlight is not convenient.

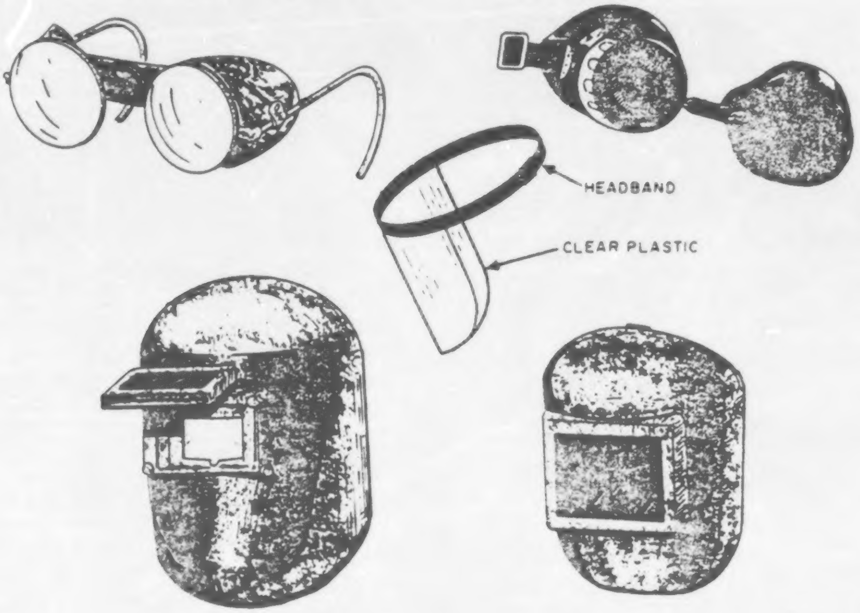
PERSONAL SAFETY EQUIPMENT

To protect you from danger, protective equipment such as safety shoes, goggles, hard hats and gloves are issued. The use of this equipment is mandatory on certain jobs. Their use is a MUST and there is no question about that. Be sure to USE THEM on any job WHERE they are REQUIRED. They can protect you from a lot of harm.

SAFETY SHOES

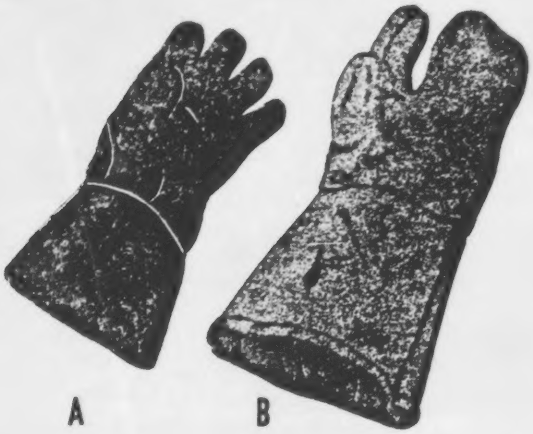
Some safety shoes are designed to limit damage to your toes from falling objects. A steel plate is placed in the toe area of such shoes so that your toes are not crushed if an object impacts there.

Other safety shoes are designed for use where danger from sparking could cause an explosion. Such danger is minimized by elimination of all metallic nails and eyelets and the use of soles which do not cause static electricity.

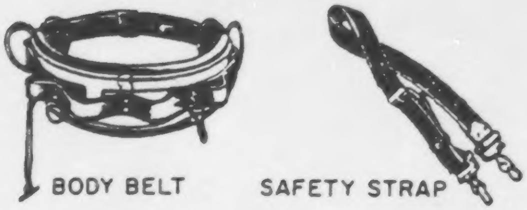


29.200

Figure 1-109.—Eye protection devices.



29.201
Figure 1-110.—Gas and electric-arc welding gauntlet gloves.



29.239.1
Figure 1-111.—Safety equipment.

26.203
Figure 1-112.—Hard hat.

GOGGLES

Proper eye protection is the utmost importance for all personnel. Eye protection is necessary because of hazards posed by infrared and ultraviolet radiation, or by flying objects such as sparks, globules of molten metal, or chipped concrete and wood, etc. These hazards are everpresent during welding, cutting, soldering, chipping, grinding and a variety of other operations. It is IMPERATIVE for you to use eye protection devices such as helmets, handshields and goggles (fig. 1-109) during eye-hazard operations.

Appropriate use of goggles will limit eye hazards. Some goggles have plastic windows which resist shattering upon impact. Others are designed to limit harmful infrared and ultraviolet radiation from arcs or flames by appropriate filter lenses.

Remember, eye damage can be excruciatingly painful. PROTECT YOUR EYES.

GLOVES

Use gloves whenever you are required to handle rough, scaly, or splintery objects. Special flameproof gloves are designed for gas and electric welding, to limit danger and damage from sparks and other hot flying objects (fig. 1-110). Personnel in the electrical fields are usually required to wear insulating rubber gloves.

Be sure to follow all regulations prescribed for the use of gloves. Gloves must not be worn around rotating machinery unless sharp or rough material is being handled. If such is the case, EXTREME CARE SHOULD BE EXERCISED to prevent the gloves from being caught in the machinery.

SAFETY BELTS AND STRAPS

The "safety strap" and "body belt" shown in figure 1-111 are what might be called your extra hands when you work aloft. The body belt, strapped around your waist contains various pockets for small tools. The safety strap is a leather or neoprene impregnated nylon belt with a tongue-type buckle at each end. While you are climbing you will have the safety strap hanging by both ends from the left ring (called a "D" ring because of its shape) on the body belt. When you are at working position, you unsnap one end of the safety strap, pass it around the supporting structure so there is no danger of its slipping (at least 18 inches from the top of the part on which it is fastened), and hook it to the right "D" ring on the body belt.

The safety strap must be placed around a part of the structure which is of sufficient strength to sustain a man's weight and his equipment, and must rest flat against the surface without twists or turns. It must not be placed around any part of a structure which is being removed. Men climbing poles at shore stations must be sure to place the straps beneath arms and braces of the poles, wherever possible.

Before placing your weight on the strap, determine VISUALLY that the snap and "D" ring are properly engaged. Do not rely on the "click" of the snap-tongue as an indication the fastening is secure.

The body belt and safety strap require inspection before use. Look for loose or broken rivets, cracks, cuts, nicks, tears or wear in leather, broken or otherwise defective buckles, such as enlarged tongue-holes, defects in safety-belt snap hooks and body belt "D" rings. If you discover any of these or other defects, turn in your equipment and replace it.

Perform maintenance periodically in accordance with applicable procedures. Remember that leather and nylon belts are treated in different manners.

PROTECTIVE HELMETS

Protective helmets (hard hats) come in a variety of shapes. They may be made of tough polyethylene or polycarbonate, one of the toughest hat materials yet developed. Many a man has had his life saved because he wore a protective hat (fig. 1-112). When a falling object struck the hat the shock-absorbing suspension capabilities minimized damage to the man's head.

Regular hard hats are required to have a degree of insulation resistance such that personnel, other than electrical, may be protected from accidental head contacts with electrical circuits and equipment at comparatively low voltages (less than 2200 volts).

Electrical workers requiring head protection incidental to their duties or to the working environment, particularly those engaged in transmission or distribution line installation and repair must wear insulating safety helmets or all-purpose protective helmets which must be capable of withstanding 20,000 volt minimum proof-tests.

BUILT-IN SAFETY EQUIPMENT

In previous paragraphs we discussed a variety of safety equipment furnished by the Navy. Don't forget about your own built-in safety equipment, however.

You have EYES to see danger, EARS to hear warnings, FEET to get away, BRAINS to know when danger is near, HANDS to help you remove or correct unsafe conditions, and a VOICE to warn your shipmates of unsafe acts. Use this safety equipment advantageously to limit accidents.

Above all, remember your ABC's.

ALWAYS

BE

CAREFUL

NO MATERIAL IS MISSING. PAGE #677 WAS OMITTED DURING PROCESSING.

CHAPTER 2

COMMON POWER TOOLS

Power tools are so commonplace in the Navy that men in all ratings use some power tools at one time or another. This chapter of the text will be devoted to the more common types of electric and air-driven power tools and equipment. Upon completion, you should be able to identify them, discuss applicable safety measures, and describe the general operating practices and care of these tools.

SAFETY

Safe practices in the use of power tools cannot be overemphasized. There are several general safety measures to observe in operating or maintaining power equipment.

- First of all, never operate power equipment unless you are thoroughly familiar with its controls and operating procedures. When in doubt, consult the appropriate operating instruction or ask someone who knows.
- All portable tools should be inspected before use to see that they are clean and in a proper state of repair.
- Have ample illumination. If extension lights are required, ensure that a light guard is provided (fig. 2-1).
- Before a power tool is connected to a source of power (electricity, air, etc.), BE SURE that the switch on the tool is in the "OFF" position.
- When operating a power tool, give it your FULL and UNDIVIDED ATTENTION.
- Keep all safety guards in position and use safety shields or goggles when necessary.
- Fasten all loose sleeves and aprons.
- DO NOT DISTRACT OR IN ANY WAY DISTURB another man while he is operating a power tool.
- Never try to clear jammed machinery unless you remove the source of power first.
- After using a power tool, turn off the power, remove the power source, wait for all rotation of the tool to stop, and then clean the tool. Remove all waste and scraps from the work area and stow the tool in its assigned location.
- Never plug the power cord of a portable electric tool into an electrical power source before ensuring that the source has the voltage and type of current (alternating or direct) called for on the nameplate of the tool.
- If an extension cord is required, always connect the cord of a portable electric power tool into the extension cord before the extension cord is inserted into a convenience outlet (fig. 2-2). Always unplug the extension cord from the receptacle before the cord of the portable power tool is unplugged from the extension cord. (The extension cord and the power cord can each be no longer than 25 feet in length. Extra extension cords should be limited, wherever possible, to maintain allowable resistance to ground.)

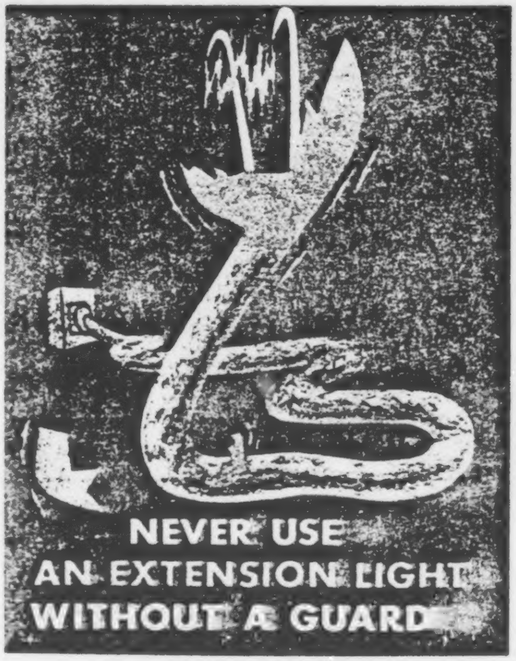


Figure 2-1.—Safety poster. 40.67(67B)A

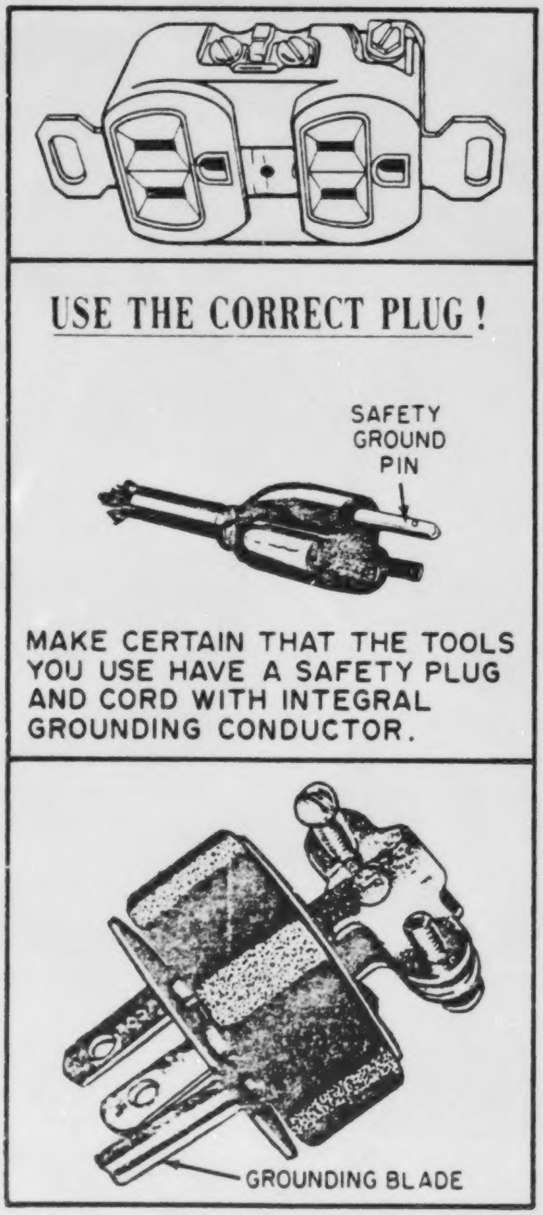

USE THE CORRECT PLUG !
SAFETY GROUND PIN
MAKE CERTAIN THAT THE TOOLS YOU USE HAVE A SAFETY PLUG AND CORD WITH INTEGRAL GROUNDING CONDUCTOR.
GROUNDING BLADE

Figure 2-2.—Grounding plugs and convenience outlet. 40.67(67C)A:5.13

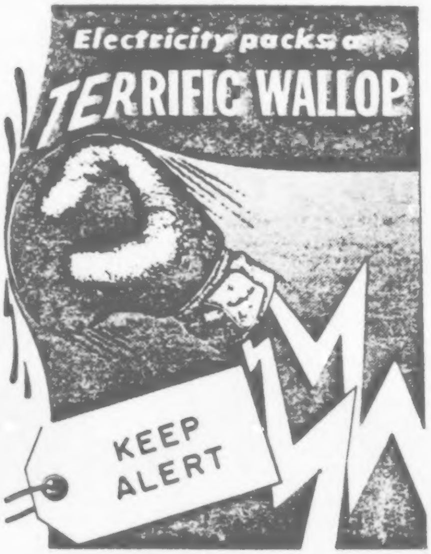
- Be sure to use a grounded plug and 3-conductor cord. Figure 2-2 shows a permanently molded type of grounded plug and also one used for replacement purposes.

The purpose of the properly grounded conductor in the 3-conductor cord is to minimize the possibility of electrical shock. The end of the grounding conductor within the tool or equipment is connected to the metal housing by the manufacturer, and the other end is connected to the grounding blade or pin of the grounded plug. In this manner, the grounding conductor simulates the mounting bolts of permanent equipment; namely, it joins the metal case of portable electric equipment to the metal of the ship's hull.

One exception to the use of 3-conductor grounded cord concerns plastic-cased tools (drills, sanders, grinders, etc.) that have been developed to eliminate the risk of electric shock. In these tools the shafts and chucks are isolated electrically from the drive motors. DO NOT replace the two-conductor cable on plastic-cased tools with 3-conductor cable IF the plastic-cased tool has an information plate on it stating that "grounding is not required"!

- Be sure that power cords do not come in contact with sharp objects. The cords should not be allowed to kink, nor should they be allowed to come in contact with oil, grease, hot surfaces, or chemicals.
- When cords are damaged, they should be replaced.
- Portable cables should be of sufficient length that they will not be subjected to longitudinal stresses or need to be pulled taut to make connections.
- Electrical portable cables should be checked frequently while in service to detect unusual heating. Any cable which feels more than comfortably warm to the bare hand placed outside the insulation should be checked immediately for overloading by competent electrical personnel.
- See that all cables are positioned so that they will not constitute tripping hazards.
- Electricity must be treated with respect and handled properly (fig. 2-3). If water exists anywhere in the vicinity of energized equipment—be especially cautious, and wherever possible, deenergize the equipment.
- Always remember:

1. ELECTRICITY strikes without warning.
2. Every electrical circuit is a POTENTIAL SOURCE OF DANGER and MUST BE TREATED AS SUCH.
3. Make no electrical repairs yourself unless you are qualified to do so.



40 67.3(111A)

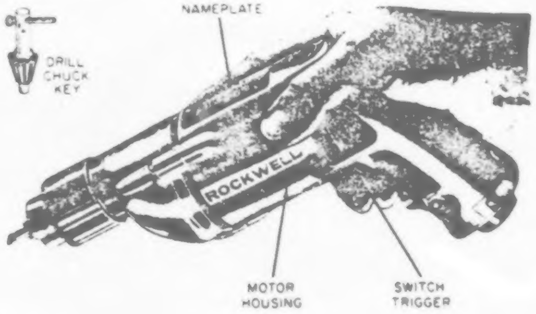
Figure 2-3.—Know what you are doing.

4. Sparking electric tools should never be used in places where flammable gases or liquids or exposed explosives are present. Pneumatic tools are used in these areas.
5. The power should always be disconnected before accessories on tools are changed.

- Shipboard conditions are particularly conducive to electric shock possibilities because the body may contact the ship's metal structure. Extra care is therefore needed, especially when body resistance may be low because of perspiration or damp clothing. Insulate yourself from ground by means of insulating material covering any adjacent grounded metal with which you might come into contact. Suitable materials include dry wood, dry canvas, dry phenolic material, several thicknesses of dry paper, or rubber mats. ALWAYS REPORT ANY SHOCK RECEIVED from electrical equipment. Minor shocks often lead to fatal shocks later on.

PORTABLE ELECTRIC POWER TOOLS

Portable power tools are tools that can be moved from place to place. Some of the most common portable power tools that you will use in the Navy are electrically powered and include drills, sanders, grinders and saws.



4.35A

Figure 2-4.—1/4-inch portable electric drill.

DRILLS

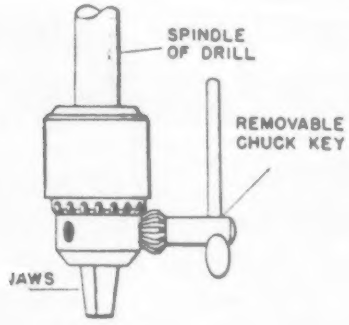
The portable electric drill (fig. 2-4) is probably the most frequently used power tool in the Navy. Although it is especially designed for drilling holes, by adding various accessories you can adapt it for different jobs. Sanding, sawing, buffing, polishing, screw-driving, wire brushing, and paint mixing are examples of possible uses.

Portable electric drills commonly used in the Navy have capacities for drilling holes in steel from 1/16 inch up to 1 inch in diameter. The sizes of portable electric drills are classified by the maximum size straight shank drill it will hold. That is, a 1/4 inch electric drill will hold a straight shank drill up to and including 1/4 inch.

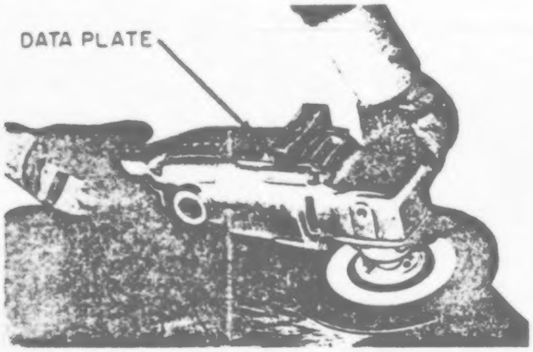
The revolutions per minute (rpm) and power the drill will deliver are most important when choosing a drill for a job. You will find that the speed of the drill motor decreases with an increase in size, primarily because the larger units are designed to turn larger cutting tools or to drill in heavy materials, and both these factors require slower speed.

If you are going to do heavy work, such as drilling in masonry or steel, then you would probably need to use a drill with a 3/8 or 1/2 inch capacity. If most of your drilling will be forming holes in wood or small holes in sheet metal, then a 1/4-inch drill will probably be adequate.

The chuck is the clamping device into which the drill is inserted. Nearly all electric drills



44.46
Figure 2-5.—Three jaw chuck and chuck key.

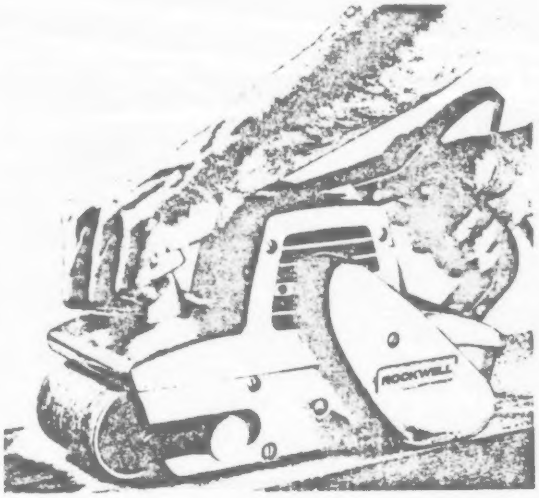


44.49X
Figure 2-6.—Portable electric sander.

are equipped with a three-jaw chuck. Some of the drill motors have a hand-type chuck that you tighten or loosen by hand but most of the drills used in the Navy have gear-type, three-jaw chucks which are tightened and loosened by means of a chuck key, shown in figure 2-5. Do not apply further pressure with pliers or wrenches after you hand tighten the chuck with the chuck key.

Always remove the key IMMEDIATELY after you use it. Otherwise the key will fly loose when the drill motor is started and may cause serious injury to you or one of your shipmates. The chuck key is generally taped on the cord of the drill; but if it is not, make sure you put it in a safe place where it will not get lost.

All portable electric drills used in the Navy have controls similar to the ones shown on the 1/4-inch drill in figure 2-4. This drill has a momentary contact trigger switch located in the handle. The switch is squeezed to start the electric drill and released to stop it.



29.139X
Figure 2-7.—Portable belt sander.

The trigger latch is a button in the bottom of the drill handle. It is pushed in, while the switch trigger is held down, to lock the trigger switch in the "ON" position. The trigger latch is released by squeezing and then releasing the switch trigger.

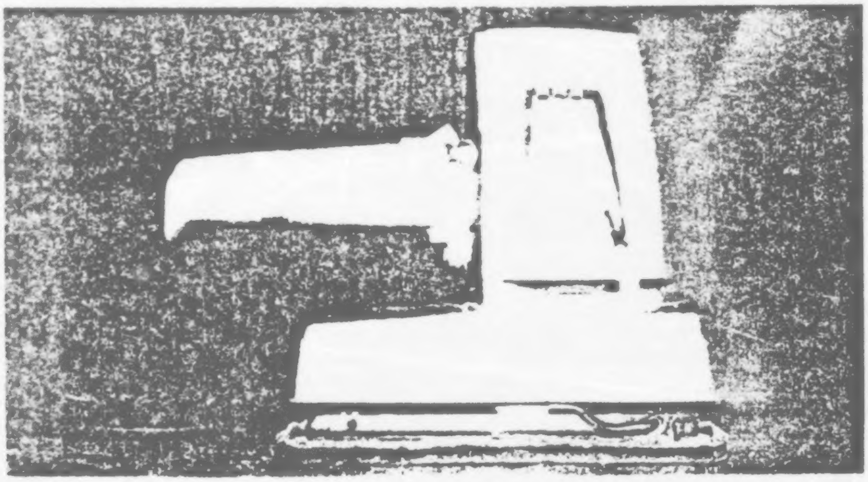
SANDERS

Portable sanders are tools designed to hold and operate abrasives for sanding wood, plastics and metals. The most common types found in the Navy are the DISK, BELT, and RECIPROCATING ORBITAL sanders.

Disk Sander

Electric disk sanders (fig. 2-6) are especially useful on work where a large amount of material is to be removed quickly such as scaling surfaces in preparation for painting. This machine, however, must not be used where a mirror smooth finish is required.

The disk should be moved smoothly and lightly over the surface. Never allow the disk to stay in one place too long because it will cut into the metal and leave a large depression.



44.50X

Figure 2-8.—Orbital sander.

Belt Sander

The belt sander (fig. 2-7) is commonly used for surfacing lumber used for interior trim, furniture, or cabinets. Wood floors are almost always made ready for final finishing by using a belt sander. Whereas these types of sanding operations were once laborious and time-consuming, it is now possible to perform the operations quickly and accurately with less effort.

The portable belt sanders use endless sanding belts that can be obtained in many different grades (grits). The belts are usually 2, 3, or 4 inches wide and can be easily changed when they become worn or when you want to use a different grade of sanding paper.

The first thing to do when preparing to use the sander is to be sure that the object to be sanded is firmly secured. Then, after the motor has been started verify that the belt is tracking on center. Any adjustment to make it track centrally is usually made by aligning screws.

The moving belt is then placed on the surface of the object to be sanded with the rear part of the belt touching first. The machine is then leveled as it is moved forward. When you use the sander, don't press down or "ride" it, because the weight of the machine exerts enough pressure for proper cutting. (Excessive pressure also causes the abrasive belt to clog and the motor to overheat). Adjust the machine over the surface with overlapping strokes, always in a direction parallel to the grain.

By working over a fairly wide area, and avoiding any machine tilting or pausing in any one spot, an even surface will result. Upon completion of the sanding process, lift the machine off the work and then stop the motor.

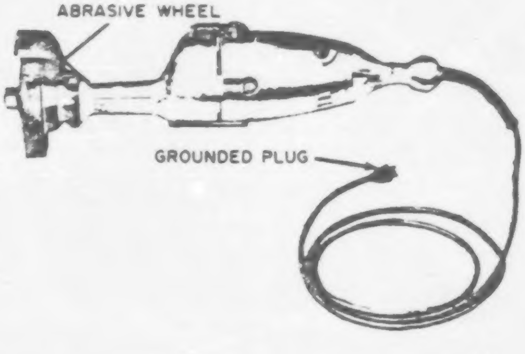
Some types of sanders are provided with a bag that takes up the dust that is produced. Use it if available.

Orbital Sander

The orbital sander (fig. 2-8) is so named because of the action of the sanding pad. The pad moves in a tiny orbit, with a motion that is hardly discernible, so that it actually sands in all directions. This motion is so small and so fast that, with fine paper mounted on the pad, it is nearly impossible to see any scratches on the finished surface.

The pad, around which the abrasive sheet is wrapped, usually extends beyond the frame of the machine so it is possible to work in tight corners and against vertical surfaces.

Some models of the orbital sanders have a bag attached to catch all dust that is made from the sanding operation. Orbital sanders (pad sanders) do not remove as much material as



44.51

Figure 2-9.—Portable grinder.

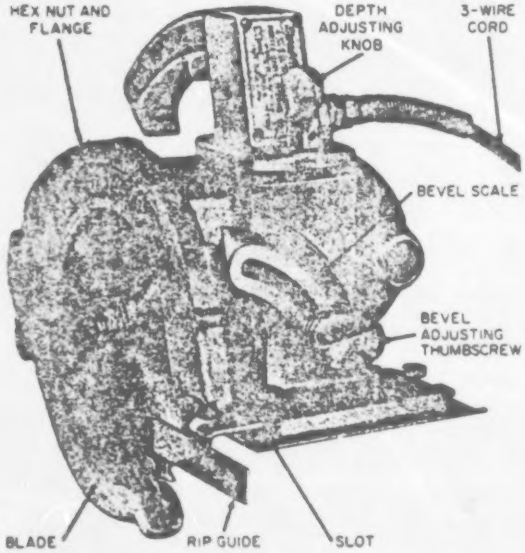
fast as the belt sander or disk sander but do a better job on smoothing a surface for finishing. If both a belt or disk sander and an orbital sander are available you should use the belt or disk sander for rough, preliminary work and the orbital sander for finishing. The sandpaper used on the sander may be cut to size from a bulk sheet of paper or may be available in the correct size for the sander you have. The paper is wrapped around a pad on the sander and is fastened to the pad by means of levers on the front and rear of the sander. The lever action fasteners make changing the paper easy and quick.

PORTABLE GRINDERS

Portable grinders are power tools that are used for rough grinding and finishing of metallic surfaces. They are made in several sizes; however, the one used most in the Navy uses a grinding wheel with a maximum diameter of 6 inches. (See fig. 2-9.)

The abrasive wheels are easily replaceable so that different grain size and grades of abrasives can be used for the varying types of surfaces to be ground and the different degrees of finish desired.

A flexible shaft attachment is available for most portable grinders. This shaft is attached by removing the grinding wheel then attaching the shaft to the grinding wheel drive spindle. The grinding wheel can then be attached to the end of the flexible shaft. This attachment is invaluable for grinding surfaces in hard to reach places.



29.133

Figure 2-10.—Portable electric circular saw.

The wheel guard on the grinder should be positioned so that abrasive dust and metal particles will be deflected away from your face.

Before you turn the grinder on, make sure the abrasive grinding wheel is properly secured to the grinder spindle and not cracked or damaged.

PORTABLE CIRCULAR SAW

The portable circular saw is becoming more and more popular as a woodworking tool because of the time and labor it saves, the precision with which it works, and its ease of handling and maneuverability.

Because of the many types of portable circular saws in the Navy supply system, and the changes being made in the design of these saws, only general information will be given in this section. Information concerning a particular saw can be found by checking the manufacturer's manual.

The sizes of portable electric saws range from one-sixth horsepower with a 4-inch blade to one-and-one half horsepower with a 14-inch blade. They are so constructed that they may be used as a carpenter's handsaw, both at the job site or on a bench in the woodworking shop.

The portable electric saw (fig. 2-10) is started by pressing a trigger inserted in the handle and stopped by releasing it. The saw will run only when the trigger is held.

Most saws may be adjusted for crosscutting or for ripping. The ripsaw guide shown in figure 2-10 is adjusted by the two small knurled nuts at the base of the saw. When the guide is inserted in the rip guide slot to the desired dimensions, the nuts are then tightened to hold it firmly in place.

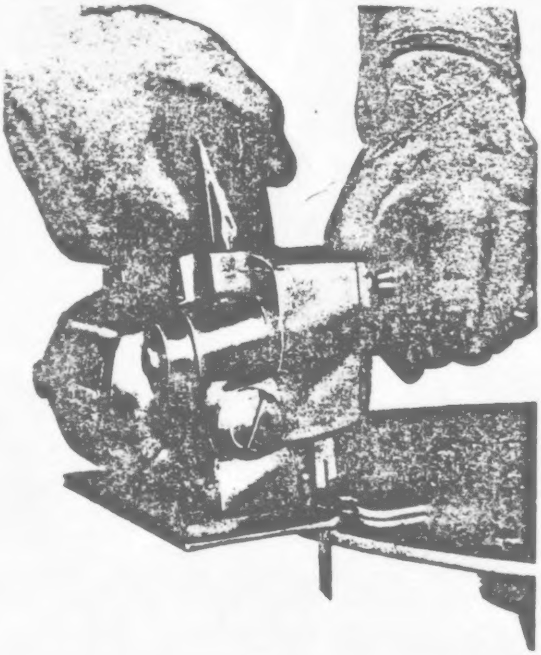
In crosscutting, a guideline is generally marked across the board to be cut. Place the front of the saw base on the work so that the guide mark on the front plate and the guide line on the work are aligned. Be sure the blade is clear of the work. Start the saw and allow the cutting blade to attain full speed. Then advance the saw, keeping the guide mark and guide line aligned. If the saw stalls, back the saw out. DO NOT RELEASE the starting trigger. When the saw resumes cutting speed, start cutting again.

Additional adjustments include a depth knob and a bevel thumbscrew. The depth of the cut is regulated by adjusting the depth knob. The bevel adjusting thumbscrew is used for adjusting the angle of the cut. This permits the base to be tilted in relation to the saw. The graduated scale marked in degrees on the quadrant (fig. 2-10) enables the operator to measure his adjustments and angles of cut.

The bottom plate of the saw is wide enough to provide the saw with a firm support on the lumber being cut. The blade of the saw is protected by a spring guard which opens when lumber is being cut but snaps back into place when the cut is finished. Many different saw blades may be placed on the machine for special kinds of sawing. By changing blades almost any building material from slate and corrugated metal sheets to fiberglass can be cut.

To change saw blades, first disconnect the power. Remove the blade by taking off the saw clamp screw and flange, using the wrench provided for this purpose. Attach the new saw blade making certain the teeth are in the proper cutting direction (pointing upward toward the front of the saw) and tighten the flange and clamp screw with the wrench.

CAUTION: Do not put the saw blade on backwards; most blades have instructions stamped on them with the words "This Side Out."



44.213X

Figure 2-11.—Saber or bayonet saw operations.

THE PORTABLE ELECTRIC SAW IS ONE OF THE MOST DANGEROUS POWER TOOLS IN EXISTENCE WHEN IT IS NOT PROPERLY USED. Make sure the board you are sawing is properly secured so it will not slip or turn. After making a cut be sure the saw blade has come to a standstill before laying the saw down.

When using an electric saw remember that all the blade you can normally see is covered; the portion of the blade that projects under the board being cut is not covered. The exposed teeth under the work are dangerous and can cause serious injury if any part of your body should come into contact with them.

Make sure the blade of a portable circular saw is kept sharp at all times. The saw blade will function most efficiently when the rate of feed matches the blade's capacity to cut. You will not have to figure this out—you will be able to feel it. With a little practice you will know when the cut is smooth and you will know when you are forcing it. Let the blade do its own cutting. The tool will last longer and you will work easier because it is less fatiguing.

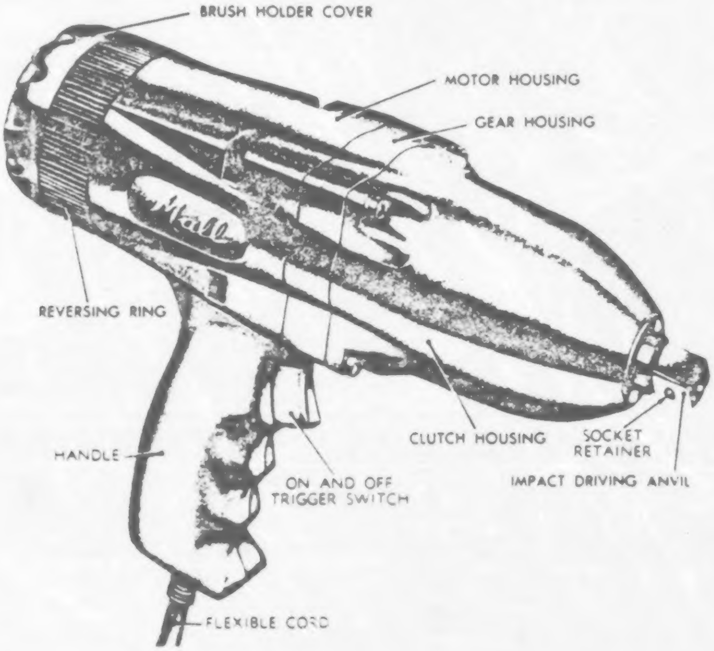


Figure 2-12.—Reversible electric impact wrench. 44.53

SABER SAW

The saber saw (fig. 2-11) is a power driven jigsaw that will let you cut smooth and decorative curves in wood and light metal. Most saber saws are light duty machines and are not designed for extremely fast cutting.

There are several different blades designed to operate in the saber saw and they are easily interchangeable. For fast cutting of wood, a blade with coarse teeth may be used. A blade with fine teeth is designed for cutting metal.

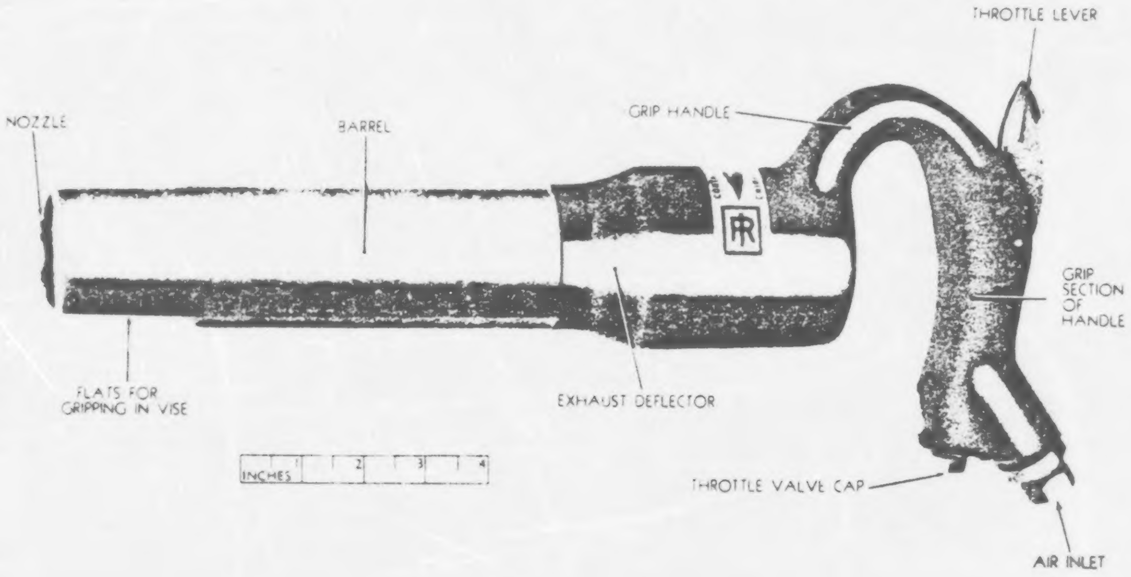
The best way to learn how to handle this type of tool is to use it. Before trying to do a finished job with the saber saw, clamp down a piece of scrap plywood and draw some curved as well as straight lines to follow. You will develop your own way of gripping the tool, and this will be affected somewhat by the particular tool you are using. On some tools, for example, you will find guiding easier if you apply some downward pressure on the tool as you move it forward. If you are not firm with your grip, the tool will tend to vibrate excessively and this will roughen the cut. Do not force the cutting faster than the design of the blade allows or you will break the blade.

ELECTRIC IMPACT WRENCH

The electric impact wrench (fig. 2-12) is a portable hand-type reversible wrench. The one shown has a 1/2-inch square impact driving anvil over which 1/2-inch square drive sockets can be fitted. Wrenches also can be obtained that have impact driving anvils ranging from 3/8 inch to 1 inch. The driving anvils are not interchangeable, however, from one wrench to another.

The electric wrench with its accompanying equipment is primarily intended for applying and removing nuts, bolts, and screws. It may also be used to drill and tap metal, wood, plastics, etc., and drive and remove socket-head, Phillips-head, or slotted-head wood, machine, or self-tapping screws.

Before you use an electric impact wrench depress the on-and-off trigger switch and allow the electric wrench to operate a few seconds, noting carefully the direction of rotation.



44.55

Figure 2-13.—Pneumatic chipping hammer.

Release the trigger switch to stop the wrench. Turn the reversing ring located at the rear of the tool; it should move easily in one direction (which is determined by the current direction of rotation). Depress the on-and-off trigger again to start the electric wrench. The direction of rotation should now be reversed. Continue to operate for a few seconds in each direction to be sure that the wrench and its reversible features are functioning correctly. When you are sure the wrench operates properly, place the suitable equipment on the impact driving anvil and go ahead with the job at hand.

PORTABLE PNEUMATIC POWER TOOLS

Portable pneumatic power tools are tools that look much the same as electric power tools but use the energy of compressed air instead [illegible] electricity. Because of the limited outlets [illegible] compressed air aboard ship and shore stations, the use of pneumatic power tools is not as widespread as electric tools. Portable pneumatic tools are used most around a shop where compressed air outlets are readily accessible.

SAFETY

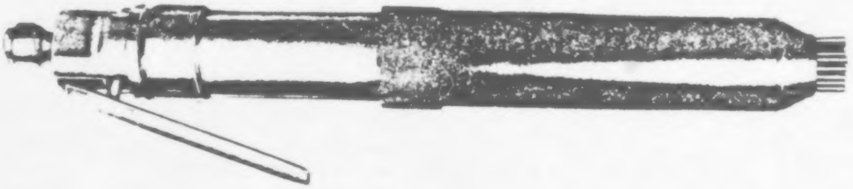
In operating or maintaining air-driven tools, take the following precautionary measures to protect yourself and others from the damaging effects of compressed air.

- Inspect the air hose for cracks or other defects; replace the hose if found defective.

- Before connecting an air hose to the compressed air outlet, open the control valve momentarily. Then, make sure the hose is clear of water and other foreign material by connecting it to the outlet and again opening the valve momentarily.

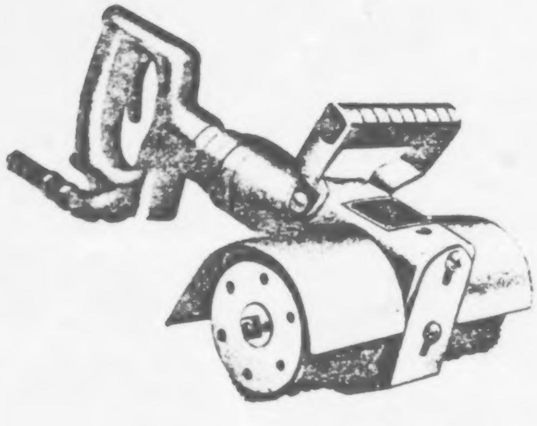
CAUTION: Before opening the control valve, see that nearby personnel are not in the path of the air flow. Never point the hose at another person.

- Stop the flow of air to a pneumatic tool by closing the control valve at the compressed air outlet before connecting, disconnecting, adjusting, or repairing a pneumatic tool.



44.214X

Figure 2-14.—Needle impact scaler.



3.209

Figure 2-15.—Rotary impact scaler.

PNEUMATIC CHIPPING HAMMER

The pneumatic chipping hammer (fig. 2-13) consists basically of a steel piston which is reciprocated (moved backward and forward alternately) in a steel barrel by compressed air. On its forward stroke the piston strikes the end of the chisel, which is a sliding fit in a nozzle pressed into the barrel. The rearward stroke is cushioned by compressed air to prevent any metal-to-metal contact. Reciprocation of the piston is automatically controlled by a valve located on the rear end of the barrel. Located on the rear end of the barrel is a grip handle, containing a throttle valve.

The throttle valve is actuated by a throttle lever which protrudes from the upper rear of the grip handle for thumb operation. Projecting from the butt of the handle is an air inlet. The handle is threaded onto the barrel and is prevented from unscrewing by a locking ring. Surrounding and retaining the locking ring is an exhaust deflector. This deflector may be located in any of four positions around the barrel in order to throw the stream of exhaust air in the desired direction.

The pneumatic hammer may be used for beveling, calking or beading operations, and for drilling in brick, concrete, and other masonry.

Chipping hammers should not be operated without safety goggles and all other persons in the immediate vicinity of the work should wear goggles.

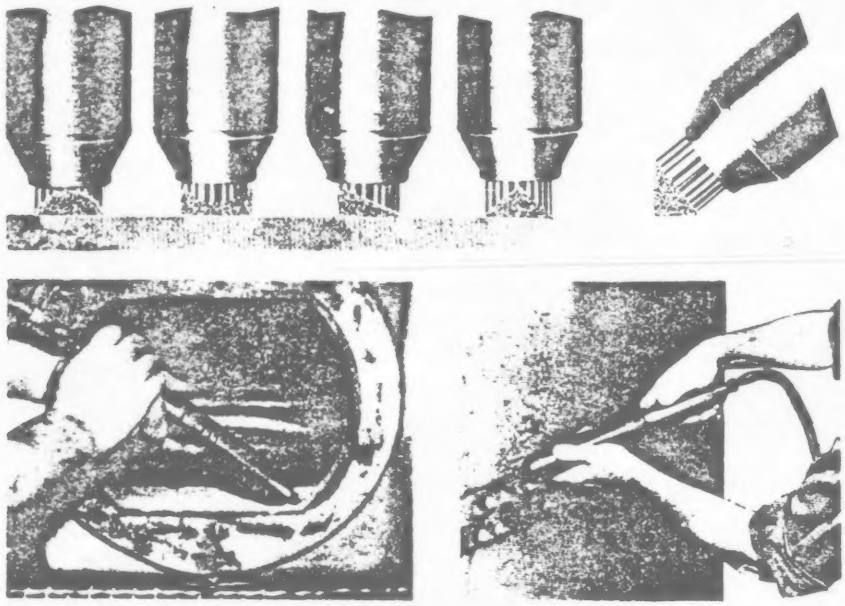
While working never point the chipping hammer in such a direction that other personnel might be struck by an accidentally ejected tool. When chipping alloy steel or doing other heavy work, it is helpful to dip the tool in engine lubricating oil about every 6 inches of the cut and make sure the cutting edge of the tool is sharp and clean. This will allow faster and easier cutting and will reduce the possibility of the tool breaking.

When nearing the end of a cut, ease off on the throttle lever to reduce the intensity of the blows. This will avoid any possibility of the chip or tool flying.

If for any reason you have to lay the chipping hammer down, always remove the attachment tool from the nozzle. Should the chipping hammer be accidentally started when the tool is free, the blow of the piston will drive the tool out of the nozzle with great force and may damage equipment or injure personnel.

NEEDLE AND ROTARY IMPACT SCALERS

Needle and rotary scalers (figs. 2-14 and 2-15) are used to remove rust, scale, and old paint from metallic and masonry surfaces. You must be especially careful when using these tools since they will "chew" up anything in their path. Avoid getting the power line or any part of your body in their way.



44.215X

Figure 2-16.—Needle scaler operations.

Needle scalers accomplish their task with an assembly of individual needles impacting on a surface hundreds of times a minute. The advantage of using individual needles is that irregular surfaces can be cleaned readily. See the operations and how the needle scaler self-adjusts to the contour of various surfaces in figure 2-16.

The rotary scaling and chipping tool, sometimes called a "jitterbug," has a bundle of cutters or chippers for scaling or chipping (fig. 2-15). In use, the tool is pushed along the surface to be scaled and the rotating chippers do the work. Replacement bundles of cutters are available when the old ones are worn.

BE SURE YOU ARE NOT DAYDREAMING when you use the rotary scaler.

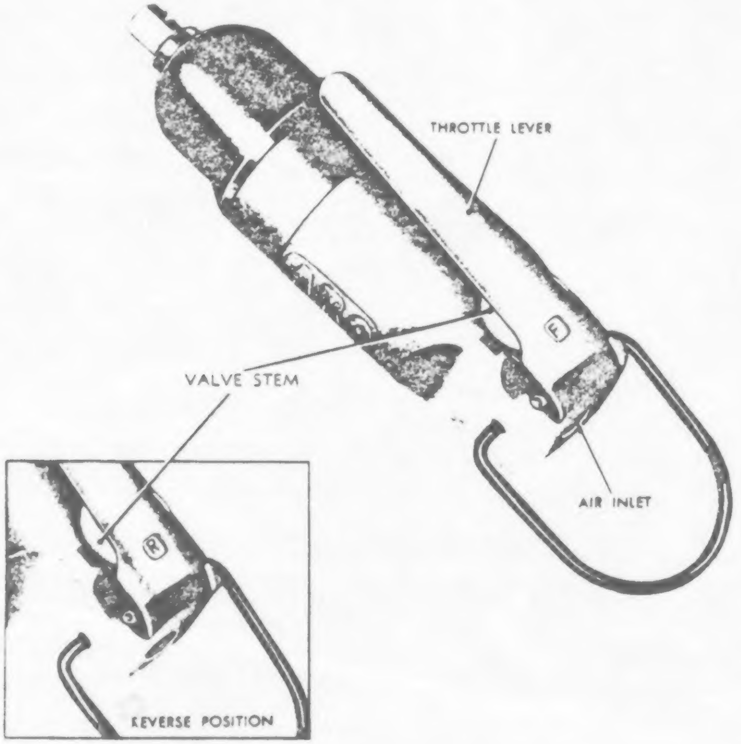
PORTABLE PNEUMATIC IMPACT WRENCH

The portable pneumatic impact wrench (fig. 2-17) is designed for installing or removing nuts and bolts. The wrench comes in different sizes and is classified by the size of the square anvil on the drive end. The anvil is equipped with a socket lock which provides positive locking of the socket wrenches or attachments. The wrench has a built-in oil reservoir and an adjustable air valve regulator which adjusts the torque output of the wrench. The torque regulator reduces the possibility of shearing or damaging threads when installing nuts and bolts to their required tension.

Nearly all pneumatic wrenches operate most efficiently on an air pressure range of 80 to 90 psi. A variation in excess of plus or minus 5 pounds is serious. Lower pressure causes a decrease in the driving speeds while higher pressure causes the wrench to overspeed with subsequent abnormal wear of the motor impact mechanisms.

The throttle lever located at the rear of the pneumatic wrench provides the means for starting and stopping the wrench. Depressing the throttle lever starts the wrench in operation. Upon release, the lever raises to its original position stopping the wrench.

The valve stem is seated beneath the pivot end of the throttle lever. Most wrenches have a window cut in the throttle lever so that the markings on the upper surface of the valve stem will be visible. Two letters, "F" and "R," have been engraved on the head of the



44.56

Figure 2-17.—Portable pneumatic impact wrench.

valve stem to indicate the forward (clockwise) and reverse (counterclockwise) rotation of the anvil. To change from forward to reverse rotation, or vice versa, turn the valve stem 180° until the desired marking is visible through the window in the throttle lever. When the valve stem is in proper position, the valve stem pin engages a recess on the under side of the valve stem, preventing accidental turning of the stem.

The air valve regulator is located at the bottom and towards the rear of the wrench. Using a screwdriver and altering the setting of the air regulator up to 90°, either to the right or left, reduces the torque from full power to zero power.

Before operating the pneumatic impact wrench make sure the socket or other attachment you are using is properly secured to the anvil. It is always a good idea to operate the wrench free of load in both forward and reverse directions to see that it operates properly. Check the installation of the air hose to make sure it is in accordance with the manufacturer's recommendation.

COMMON POWER MACHINE TOOLS

Small power machine tools are, generally speaking, not portable. All work that is to be done must be brought to the shop where the machine is set up. Only the most common types of power machine tools will be discussed in this chapter. The drill press and the bench grinder may be found in several shops aboard ship or on shore stations. They are tools that are not confined to operation by men of any one particular rating but may be used by men of several ratings.

DRILL PRESS

The drill press (fig. 2-18) is an electrically operated power machine that was originally designed as a metal-working tool. Available

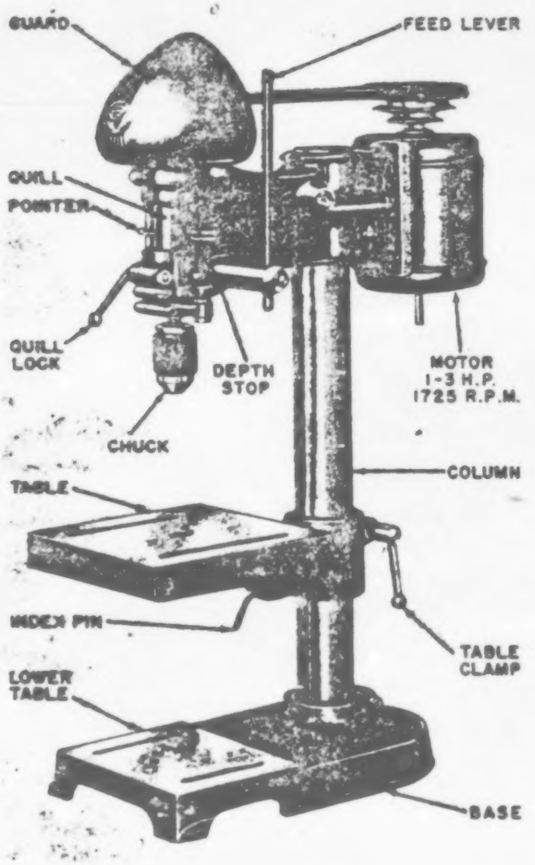


Figure 2-18.—Drill press. 4.29

accessories, plus jigs and special techniques, now make it a versatile wood-working tool as well.

There are two basic types of drill presses used in the Navy; the bench-type and the upright-type. These are basically the same, the difference being in the mounting. As the names suggest, the bench-type drill press is mounted on a work bench and the upright-type drill press is mounted on a pedestal on the floor.

Drill presses are manufactured in a number of sizes. Only the small size drill press will be discussed in this text. The drill presses most commonly found in shops in the Navy have a capacity to drill holes in metal up to 1 inch in diameter. The driving motors range in size from 1/3 hp to 3 hp.

The motor is mounted to a bracket at the rear of the head assembly and designed to permit V-belt changing for desired spindle speed without removing the motor from its mounting bracket. Four spindle speeds are obtained by locating the V-belt on any one of the four steps of the spindle-driven and motor-driven pulleys.

The controls of drill presses are all similar. The terms "right" and "left" are relative to the operator's position standing in front of and facing the drill press. Forward applies to movement toward the operator. Rearward applies to movement away from the operator.

The power switch (fig. 2-19) is located on the right side of the head assembly. The power cord is placed in the power receptacle and the motor started by placing the switch in the "ON" position.

The spindle and quill feed handle (fig. 2-19) is located on the lower right-front side of the head assembly. Pulling forward and down on any one of the three spindle and quill feed handles, which point upward at the time, moves the spindle and quill assembly downward. Release the feed handle and the spindle and quill assembly will return to the retracted or upper position by spring action.

The quill lock handle (fig. 2-20) enables the drill press to be used as a milling tool and is located at the lower left-front side of the head assembly. Turn the quill lock handle clockwise to lock the quill at a desired operating position. Release the quill by turning the quill lock handle counterclockwise. However, in most cases, the quill lock handle will be in the released position.

The head lock handle (fig. 2-20) is located at the left-rear side of the head assembly. Turn the head lock handle clockwise to lock the head assembly at a desired vertical height on the bench column. Turn the headlock handle counterclockwise to release the head assembly. When operating the drill press, the head lock handle must be tight at all times.

The head collar support lock handle (fig. 2-19) is located at the right side of the head collar support and below the head assembly. The handle locks the head collar support, which secures the head vertically on the bench column, and prevents the head from dropping when the head lock handle is released. Turn the head

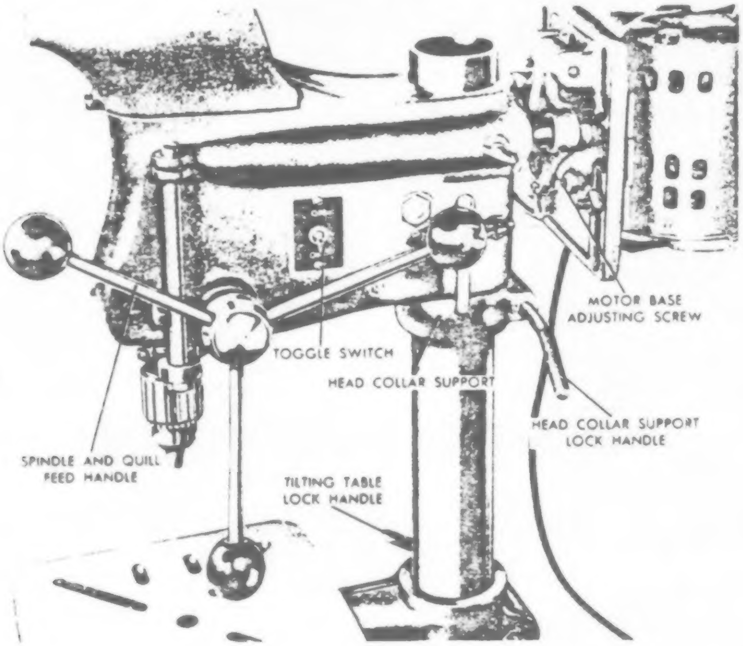

MOTOR BASE ADJUSTING SCREW
TOGGLE SWITCH
HEAD COLLAR SUPPORT
HEAD COLLAR SUPPORT LOCK HANDLE
SPINDLE AND QUILL FEED HANDLE
TILTING TABLE LOCK HANDLE
4.29

Figure 2-19.—Drill press controls—right side view.

collar support lock handle clockwise to lock the support to the bench column and counterclockwise to release the support. When operating the drill press, the head collar support lock handle must be tight at all times.

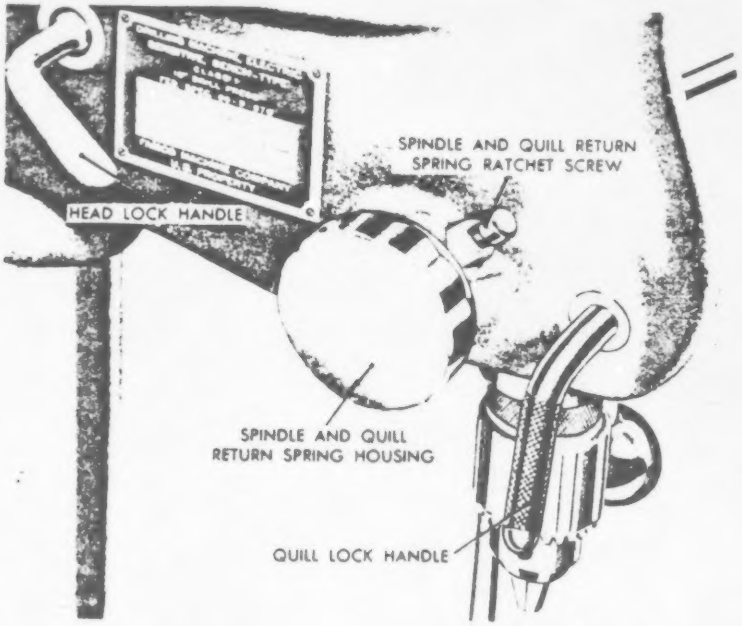
The tilting table lock handle (fig. 2-19) is located at the left-rear side of the tilting table bracket. Turn the tilting table lock handle counterclockwise to release the tilting table bracket so it can be moved up and down or around the bench column. Lock the tilting table assembly at desired height by turning the lock handle clockwise. When operating the drill press, the tilting table lock handle must be tight at all times.

The tilting table lockpin (S, fig. 2-21) is located below the tilting table assembly (T, fig. 2-21). The lockpin secures the table at a horizontal or 45° left or right from the horizontal position. To tilt the table left or right from its horizontal position, remove the lockpin and turn the table to align the lockpin holes. Insert the lockpin through the table and bracket holes after desired position is obtained.

The depth gage rod adjusting and locknuts (BB and CC, fig. 2-21) are located on the depth gage rod (Z, fig. 2-21). The purpose of the adjusting and locknuts is to regulate depth drilling. Turn the adjusting and locknut clockwise to decrease the downward travel of the spindle. The locknut must be secured against the adjusting nut when operating the drill press.

When operating a drill press make sure the drill is properly secured in the chuck and that the work you are drilling is properly secured in position. Do not remove the work from the tilting table or mounting device until the drill press has stopped.

Operate the spindle and quill and feed handles with a slow, steady pressure. If too much pressure is applied, the V-belt may slip in the pulleys, the twist drill may break, or the starting switch in the motor may open and stop the drill press. If the motor should stop because of overheating, the contacts of the starting switch will remain open long enough for the motor to cool, then automatically close to resume normal operation. Always turn the toggle switch to "OFF" position while the motor is cooling.


SPINDLE AND QUILL RETURN SPRING RATCHET SCREW
HEAD LOCK HANDLE
SPINDLE AND QUILL RETURN SPRING HOUSING
QUILL LOCK HANDLE

44.60

Figure 2-20.—Drill press controls—left side view.

Check occasionally to make sure all locking handles are tight, and that the V-belt is not slipping and adjust as necessary in accordance with the manufacturer's manual.

Before operating any drill press, visually inspect the drill press to determine if all parts are in the proper place, secure, and in good operating condition. Check all assemblies, such as the motor, head, pulleys, and bench for loose mountings.

While the drill press is operating, be alert for any sounds that may be signs of trouble, such as squeaks or unusual noise. Report any unusual or unsatisfactory performance to the petty officer in charge of the shop.

After operating a drill press, wipe off all dirt, oil, and metal particles. Inspect the V-belt to make sure no metal chips are imbedded in the driving surfaces.

BENCH GRINDER

The electric bench grinder (fig. 2-22) is designed for hand grinding operations, such as sharpening chisels or screw drivers, grinding drills, removing excess metal from work, and smoothing metal surfaces. It is usually fitted with both a medium grain and fine grain abrasive wheel; the medium wheel is satisfactory for rough grinding where a considerable quantity of metal has to be removed, or where a smooth finish is not important. For sharpening tools or grinding to close limits of size, the fine wheel should be used as it removes metal slower, gives the work a smooth finish and does not generate enough heat to anneal the cutting edges.

When a deep cut is to be taken on work or a considerable quantity of metal removed, it is often practical to grind with the medium wheel first and finish up with the fine wheel. Most bench grinders are so made that wire brushes, polishing wheels, or buffing wheels can be substituted for the removable grinding wheels.

To protect the operator during the grinding operation, an eye shield and wheel guard are provided for each grinding wheel. A tool rest is provided in front of each wheel to rest and

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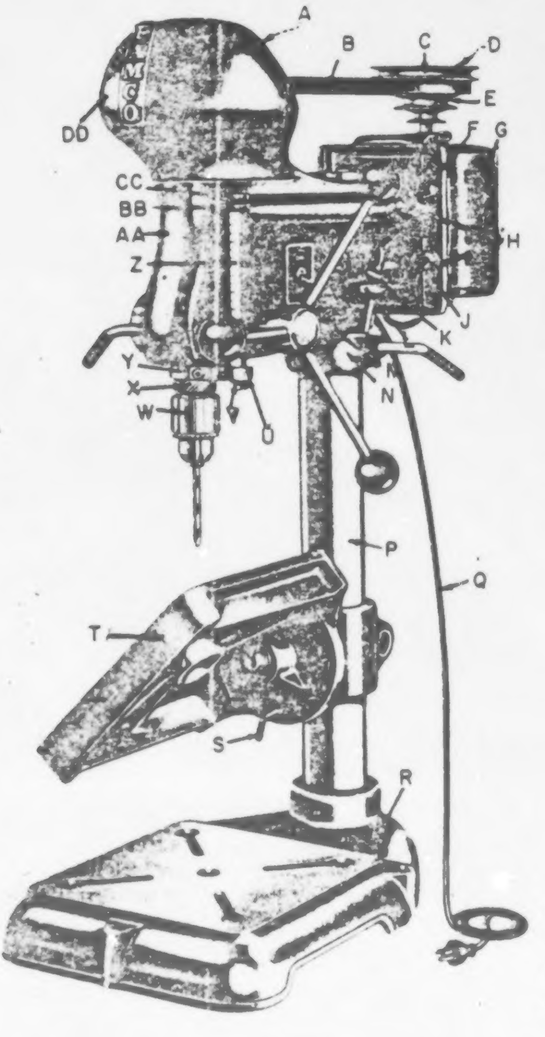


A	SPINDLE DRIVEN PULLEY
B	V-BELT
C	MOTOR DRIVE PULLEY
D	1/8 SQ x 1 SQ-END KEY
E	NO 10-24 x 5/8 HDLS SET SCREW
F	MOTOR BRACKET STUD THUMBSCREW
G	MOTOR
H	MOTOR BASE AND BRACKET ASSEMBLY
J	1/4-20NC 2 x 1 SQ-NECK RD-HD CARRIAGE BOLT AND 1/4-20NC-2 SQ NUT
K	DRILL CHUCK KEY
L	DRILL CHUCK KEY BRACKET
M	TOGGLE SWITCH PLATE
N	HEAD COLLAR SUPPORT
P	BENCH COLUMN
Q	CORD
R	BENCH BASE
S	TILTING TABLE LOCKPIN
T	TILTING TABLE ASSEMBLY
U	DEPTH GAGE ROD BRACKET
V	HEX NUT
W	DRILL CHUCK
X	CHUCK KNOCKOUT COLLAR
Y	SPINDLE AND QUILL ASSEMBLY
Z	DEPTH GAGE ROD
AA	HEAD ASSEMBLY
BB	DEPTH GAGE ROD ADJUSTING NUT
CC	DEPTH GAGE ROD LOCKNUT
DD	SPINDLE DRIVEN PULLEY GUARD

4.29

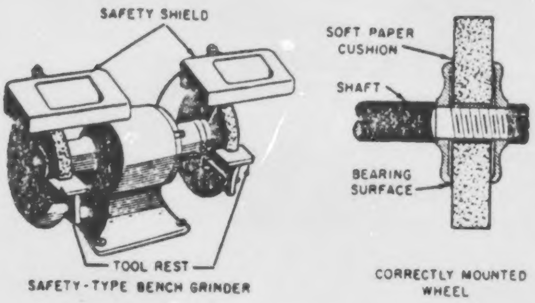
Figure 2-21.—Drill press nomenclature.

guide the work during the grinding procedure. The rests are removable, if necessary, for grinding odd-shaped or large work.

When starting a grinder, turn it on and stand to one side until the machine comes up to full speed. There is always a possibility that a wheel may fly to pieces when coming up to full speed. Never force work against a cold wheel; apply work gradually to give the wheel an opportunity to warm. You thereby minimize the possibility of breakage.

Handle grinding wheels carefully. Before replacing a wheel always check it for cracks. Make sure that a fiber or rubber gasket is in place between each side of the wheel and its retaining washer. Tighten the spindle nut just enough to hold the wheel firmly; if the nut is tightened too much the clamping strain may

1044


SAFETY SHIELD
SOFT PAPER CUSHION
SHAFT
BEARING SURFACE
TOOL REST
SAFETY-TYPE BENCH GRINDER
CORRECTLY MOUNTED WHEEL

4.31

Figure 2-22.—Bench grinder and wheel.

damage the wheel. When selecting a replacement wheel, ascertain that the grinder will not exceed the manufacturer's recommended speed for the wheel.

When grinding, always keep the work moving across the face of the wheel; grinding against the same spot on the wheel will cause grooves to be worn into the face of the wheel. Keep all wheel guards tight and in place. Always keep the tool rest adjusted so that it just clears the wheel and is at or just below the center line of the wheel, to prevent accidental jamming of work between tool rest and wheel.

Wear goggles, even if eye shields are attached to the grinder. Keep your thumbs and fingers out of the wheel.

with
power
tools
CONCENTRATE
don't AMPUTATE!

CHAPTER 3

MEASURING TOOLS AND TECHNIQUES

In performing many jobs during your Navy career, you will be required to take accurate measurements of materials and objects. It is common practice in the Navy to fabricate material for installation on a ship or in the field. For example, suppose you need a box of certain size to fit a space in a compartment. You would have to take measurements of the space and send them to a shop where the box would be built. This example suggests that the measurements you took and those taken in the process of building the box must be accurate. However, the accuracy of the measurements will depend on the measuring tools used and one's ability to use them correctly.

Measuring tools are also used for inspecting a finished product or partly finished product. Inspection operations include testing or checking a piece of work by comparing dimensions of the workpiece to the required dimensions given on a drawing or sketch. Again, the measurements taken must be accurate and accuracy depends on one's ability to use measuring tools correctly.

After studying this chapter, you should be able to select the appropriate measuring tool to use in doing a job and be able to operate properly a variety of measuring instruments.

RULES AND TAPES

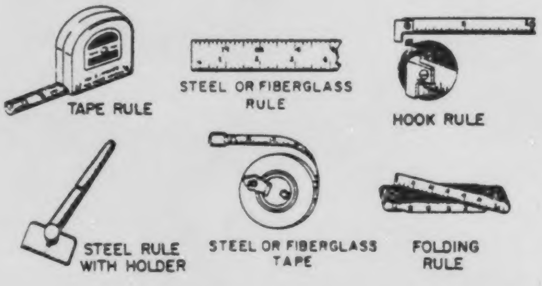
There are many different types of measuring tools in use in the Navy. Where exact measurements are required, a micrometer caliper (mike) is used. Such a caliper, when properly used, gives measurements to within .001 of an inch accuracy. On the other hand, where accuracy is not extremely critical, the common rule or tape will suffice for most measurements.

Figure 3-1 shows some of the types of rules and tapes commonly used in the Navy. Of all measuring tools, the simplest and most common is the steel rule. This rule is usually 6 or 12 inches in length, although other lengths are available. Steel rules may be flexible or nonflexible, but the thinner the rule, the easier it is to measure accurately because the division marks are closer to the work.

Generally a rule has four sets of graduations, one on each edge of each side. The longest lines represent the inch marks. On one edge, each inch is divided into 8 equal spaces; so each space represents 1/8 in. The other edge of this side is divided into sixteenths. The 1/4-in. and 1/2-in. marks are commonly made longer than the smaller division marks to facilitate counting, but the graduations are not, as a rule, numbered individually, as they are sufficiently far apart to be counted without difficulty. The opposite side is similarly divided into 32 and 64 spaces per inch, and it is common practice to number every fourth division for easier reading.

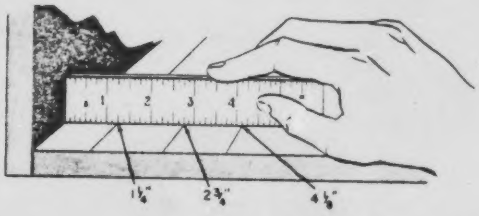
There are many variations of the common rule. Sometimes the graduations are on one side only, sometimes a set of graduations is added across one end for measuring in narrow spaces, and sometimes only the first inch is divided into 64ths, with the remaining inches divided into 32nds and 16ths.

A metal or wood folding rule may be used for measuring purposes. These folding rules are usually 2 to 6 feet long. The folding rules cannot be relied on for extremely accurate measurements because a certain amount of play develops at the joints after they have been used for a while.

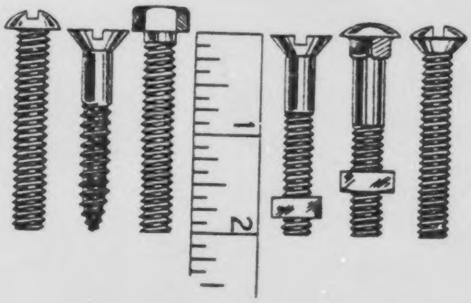


44.24

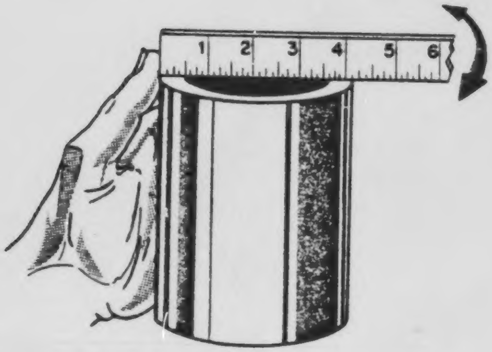
Figure 3-1.—Some common types of rules.



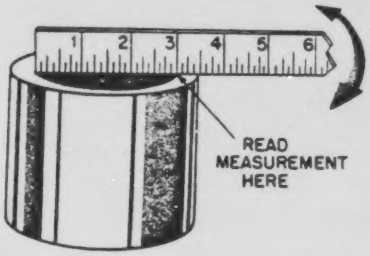
44.66
Figure 3-2.—Measuring with and reading a common rule.



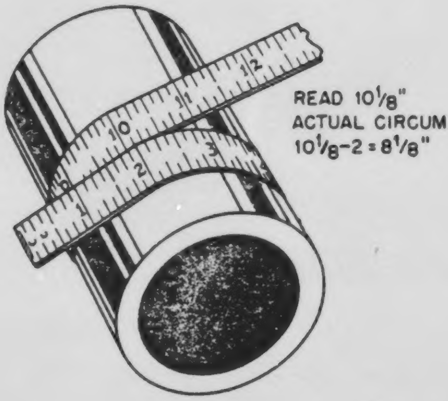
29.124A
Figure 3-3.—Measuring the length of a bolt or screw.



44.67
Figure 3-4.—Measuring the outside diameter of a pipe.



44.68
Figure 3-5.—Measuring the inside diameter of a pipe.



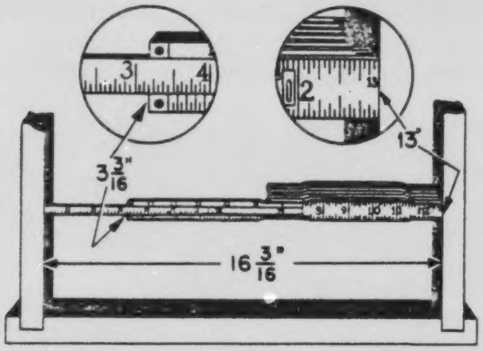
44.69
Figure 3-6.—Measuring the circumference of a pipe with a tape.

Steel tapes are made from 6 to about 300 ft. in length. The shorter lengths are frequently made with a curved cross section so that they are flexible enough to roll up, but remain rigid when extended. Long, flat tapes require support over their full length when measuring, or the natural sag will cause an error in reading.

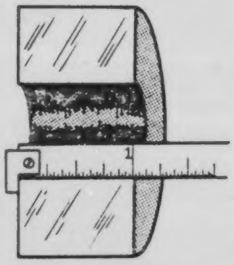
The flexible-rigid tapes are usually contained in metal cases into which they wind themselves when a button is pressed, or into which they can be easily pushed. A hook is provided at one end to hook over the object being measured so one man can handle it without assistance. On some models, the outside of the case can be used as one end of the tape when measuring inside dimensions.

MEASURING PROCEDURES

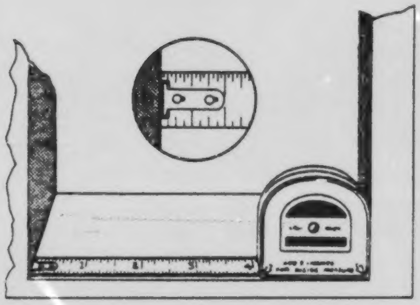
To take a measurement with a common rule, hold the rule with its edge on the surface of the object being measured. This will eliminate parallax and other errors which might result



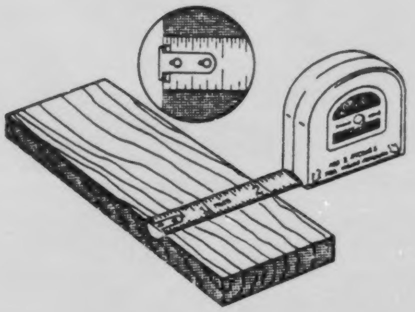
44.26.6
Figure 3-7.—Using a folding rule to measure an inside dimension.



44.70
Figure 3-9.—Measuring the thickness of stock through a hole.



44.24.1A
Figure 3-8.—Measuring an inside dimension with a tape rule.



44.24.1B
Figure 3-10.—Measuring an outside dimension using a tape rule.

due to the thickness of the rule. Read the measurement at the graduation which coincides with the distance to be measured, and state it as being so many inches and fractions of an inch. (Fig. 3-2.) Always reduce fractions to their lowest terms, for example, 6/8 inch would be called 3/4 inch. A hook or eye at the end of a tape or rule is normally part of the first measured inch.

Bolts or Screws

The length of bolts or screws is best measured by holding them up against a rigid rule or tape. Hold both the bolt or screw to be measured and the rule up to your eye level so that your line of sight will not be in error in reading the measurement. As shown in figure 3-3, the bolts or screws with countersink type heads are measured from the top of the head to the opposite end, while those with other type heads are measured from the bottom of the head.

Outside Pipe Diameters

To measure the outside diameter of a pipe, it is best to use some kind of rigid rule. A folding wooden rule or a steel rule is satisfactory for this purpose. As shown in figure 3-4, line up the end of the rule with one side of the pipe, using your thumb as a stop. Then with the one end held in place with your thumb, swing the rule through an arc and take the maximum reading at the other side of the pipe. For most practical purposes, the measurement obtained

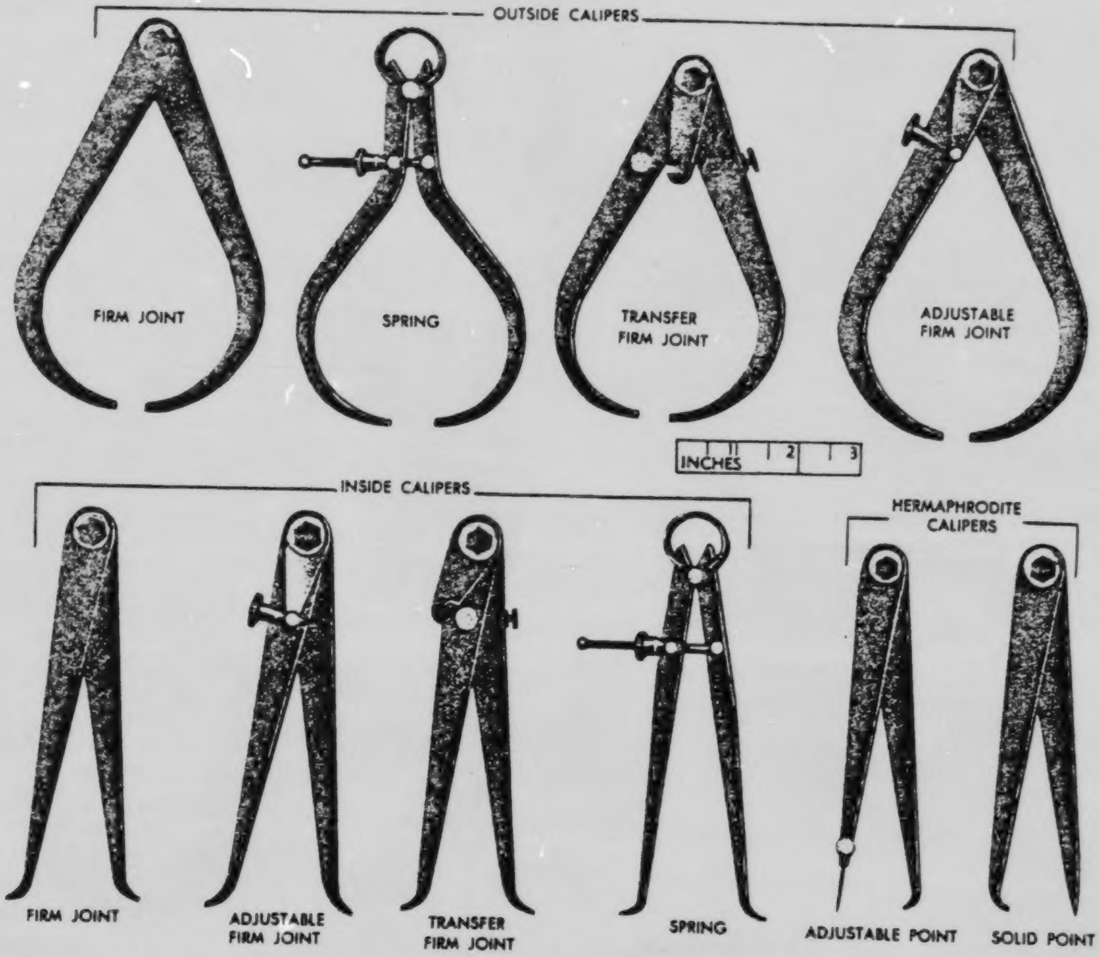

OUTSIDE CALIPERS
FIRM JOINT
SPRING
TRANSFER FIRM JOINT
ADJUSTABLE FIRM JOINT
INCHES
1
2
3
INSIDE CALIPERS
HERMAPHRODITE CALIPERS
FIRM JOINT
ADJUSTABLE FIRM JOINT
TRANSFER FIRM JOINT
SPRING
ADJUSTABLE POINT
SOLID POINT

Figure 3-11.—Simple calipers—noncalibrated. 4.17A

by using this method is satisfactory. It is necessary that you know how to take this measurement as the outside diameter of pipe is sometimes the only dimension given on pipe specifications.

Inside Pipe Diameters

To measure the inside diameter of a pipe with a rule, as shown in figure 3-5, hold the rule so that one corner of the rule just rests on the inside of one side of the pipe. Then, with one end thus held in place, swing the rule through an arc and read the diameter across the maximum inside distance. This method is satisfactory for an approximate inside measurement.

Pipe Circumferences

To measure the circumference of a pipe, a flexible type rule that will conform to the cylindrical shape of the pipe must be used. A tape rule or a steel tape is adaptable for this job. When measuring pipe, make sure the tape has been wrapped squarely around the axis of the pipe (i.e., measurement should be taken in a plane perpendicular to the axis) to ensure that the reading will not be more than the actual circumference of the pipe. This is extremely important when measuring large diameter pipe.

Hold the rule or tape as shown in figure 3-6. Take the reading, using the 2-inch graduation, for example, as the reference point. In this case the correct reading is found by subtracting 2 inches from the actual reading. In this way the first 2 inches of the tape, serving as a handle, will enable you to hold the tape securely.

Inside Dimensions

To take an inside measurement, such as the inside of a box, a folding rule that incorporates a 6- or 7-inch sliding extension is one of the best measuring tools for this job. To take the inside measurement, first unfold the folding rule to the approximate dimension. Then extend the end of the rule and read the length that it extends, adding the length of the extension to the length on the main body of the rule. (Fig. 3-7.) In this illustration the length of the main body of the rule is 13 inches and the extension is pulled out 3 3/16 inches. In this case the total inside dimension being measured is 16 3/16 inches.

In figure 3-8 notice in the circled insert that the hook at the end of the particular rule shown is attached to the rule so that it is free to move slightly. When an outside dimension is taken by hooking the end of the rule over an edge, the hook will locate the end of the rule even with the surface from which the measurement is being taken. By being free to move, the hook will retract away from the end of the rule when an inside dimension is taken. To measure an inside dimension using a tape rule, extend the rule between the surfaces as shown, take a reading at the point on the scale where the rule enters the case, and add 2 inches. The 2 inches are the width of the case. The total is the inside dimension being taken.

To measure the thickness of stock through a hole with a hook rule, insert the rule through the hole, hold the hook against one face of the stock, and read the thickness at the other face. (Fig. 3-9.)

Outside Dimensions

To measure an outside dimension using a tape rule, hook the rule over the edge of the stock. Pull the tape out until it projects far enough from the case to permit measuring the required distance. The hook at the end of the rule is designed so that it will locate the end of the rule at the surface from which the measurement is being taken. (Fig. 3-10.) When taking a measurement of length, the tape is held parallel to the lengthwise edge. For measuring widths, the tape should be at right angles to the lengthwise edge. Read the dimension of the rule exactly at the edge of the piece being measured.

It may not always be possible to hook the end of the tape over the edge of stock being measured. In this case it may be necessary to butt the end of the tape against another surface or to hold the rule at a starting point from which a measurement is to be taken.

Distance Measurements

Steel or fiberglass tapes are generally used for making long measurements. Secure the hook end of the tape. Hold the tape reel in the hand and allow it to unwind while walking in the direction in which the measurement is to be taken. Stretch the tape with sufficient tension to overcome sagging. At the same time make sure the tape is parallel to an edge or the surface being measured. Read the graduation on the tape by noting which line on the tape coincides with the measurement being taken.

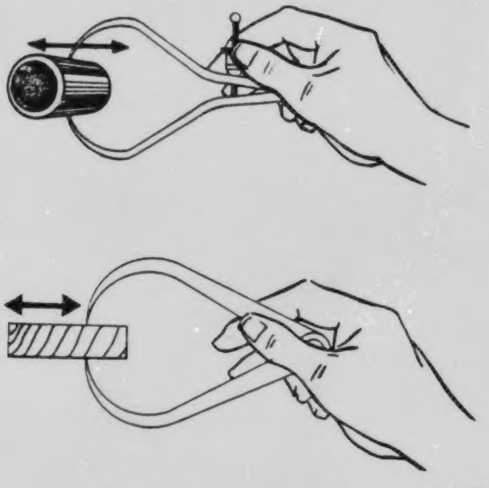
CARE

Rules and tapes should be handled carefully and kept lightly oiled to prevent rust. Never allow the edges of measuring devices to become nicked by striking them with hard objects. They should preferably be kept in a wooden box when not in use.

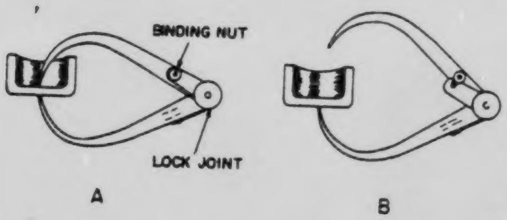
To avoid kinking tapes, pull them straight out from their cases—do not bend them backward. With the windup type, always turn the crank clockwise—turning it backward will kink or break the tape. With the spring-wind type, guide the tape by hand. If it is allowed to snap back, it may be kinked, twisted, or otherwise damaged. Do not use the hook as a stop. Slow down as you reach the end.

SIMPLE CALIPERS

Simple calipers are used in conjunction with a scale to measure diameters. The calipers most commonly used in the Navy are shown in figure 3-11.



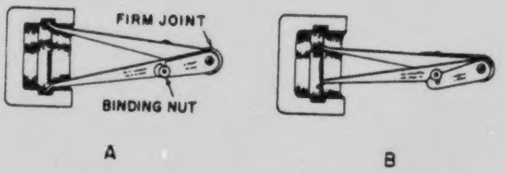
4.17B
Figure 3-12.—Using an outside caliper.



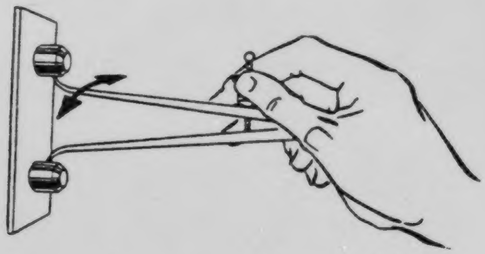
4.17C
Figure 3-13.—Measuring the thickness of the bottom of a cup.

Outside calipers for measuring outside diameters are bow-legged; those used for inside diameters have straight legs with the feet turned outward. Calipers are adjusted by pulling or pushing the legs to open or close them. Fine adjustment is made by tapping one leg lightly on a hard surface to close them, or by turning them upside down and tapping on the joint end to open them.

Spring-joint calipers have the legs joined by a strong spring hinge and linked together by a screw and adjusting nut. For measuring chamfered cavities (grooves), or for use over flanges, transfer calipers are available. They are equipped with a small auxiliary leaf attached to one of the legs by a screw. (Fig. 3-11.) The measurement is made as with ordinary calipers; then the leaf is locked to the leg. The legs may then be opened or closed as needed to clear the obstruction, then brought back and locked to the leaf again, thus restoring them to the original setting.



4.17D
Figure 3-14.—Measuring a hard to reach inside dimension with an inside caliper.



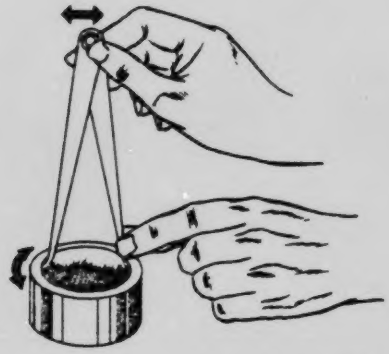
4.17E
Figure 3-15.—Measuring the distance between two surfaces with an inside caliper.

A different type of caliper is the hermaphrodite, sometimes called odd-leg caliper. This caliper has one straight leg ending in a sharp point, sometimes removable, and one bow leg. The hermaphrodite caliper is used chiefly for locating the center of a shaft, or for locating a shoulder.

USING CALIPERS

A caliper is usually used in one of two ways. Either the caliper is set to the dimension of the work and the dimension transferred to a scale, or the caliper is set on a scale and the work machined until it checks with the dimension set up on the caliper. To adjust a caliper to a scale dimension, one leg of the caliper should be held firmly against one end of the scale and the other leg adjusted to the desired dimension. To adjust a caliper to the work, open the legs wider than the work and then bring them down to the work.

CAUTION: Never place a caliper on work that is revolving in a machine.



4.17F

Figure 3-16.—Measuring an inside diameter with an inside caliper.

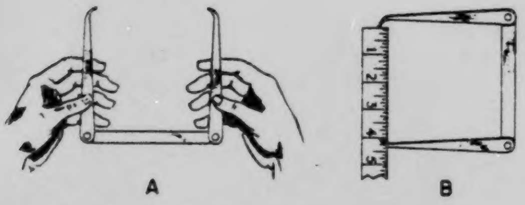


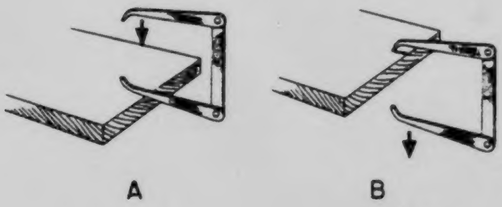
Figure 3-17.—Setting a combination firm joint caliper. 44.97

Measuring The Diameter of Round or The Thickness of Flat Stock

To measure the diameter of round stock, or the thickness of flat stock, adjust the outside caliper so that you feel a slight drag as you pass it over the stock. (See fig. 3-12.) After the proper "feel" has been attained, measure the setting of the caliper with a rule. In reading the measurement, sight over the leg of the caliper after making sure the caliper is set squarely with the face of the rule.

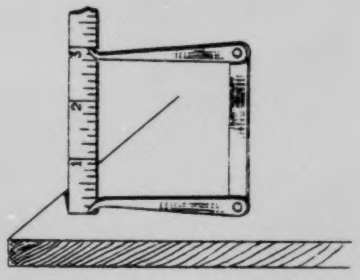
Measuring Hard to Reach Dimensions

To measure an almost inaccessible outside dimension, such as the thickness of the bottom of a cup, use an outside transfer firm-joint caliper as shown in figure 3-13. When the proper "feel" is obtained, tighten the lock joint.



44.97A

Figure 3-18.—Decreasing and increasing the setting of a firm joint caliper.



44.97B

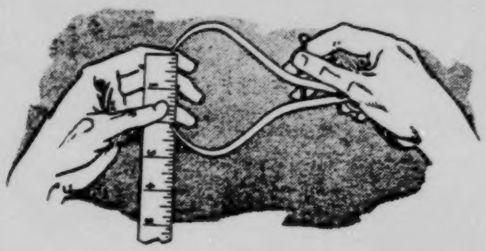
Figure 3-19.—Setting a combination firm joint caliper for inside measurements.

Then loosen the binding nut and open the caliper enough to remove it from the cup. Close the caliper again and tighten the binding nut to seat in the slot at the end of the auxiliary arm. The caliper is now at the original setting, representing the thickness of the bottom of the cup. The caliper setting can now be measured with a rule.

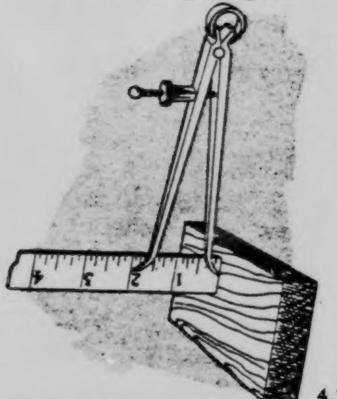
To measure a hard to reach inside dimension, such as the internal groove shown in figure 3-14, a lock-joint inside caliper should be used. The procedure followed for measuring a hard to reach outside dimension is used.

Measuring The Distance Between Two Surfaces

To measure the distance between two surfaces with an inside caliper, first set the caliper to the approximate distance being measured. Hold the caliper with one leg in contact with one of the surfaces being measured. (See fig. 3-15.) Then as you increase the setting of the caliper, move the other leg from left to right. Feel for



4.17G
Figure 3-20.—Setting an outside spring caliper.



4.17H
Figure 3-21.—Setting an inside spring caliper.

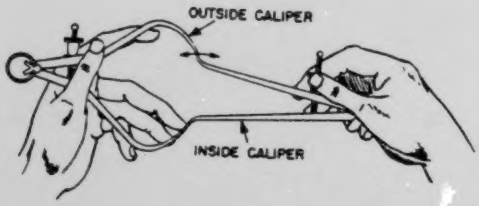
the slight drag indicating the proper setting of the caliper. Then remove the caliper and measure the setting with a rule.

Measuring Hole Diameters

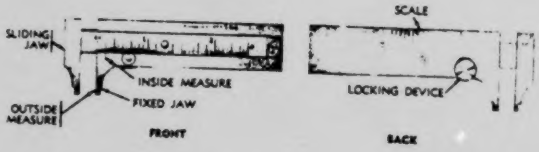
To measure the diameter of a hole with an inside caliper, hold the caliper with one leg in contact with one side of the hole (fig. 3-16) and, as you increase the setting, move the other leg from left to right, and in and out of the hole. When you have found the point of largest diameter, remove the caliper and measure the caliper setting with a rule.

Setting A Combination Firm Joint Caliper

To set a combination firm joint caliper with a rule, when the legs are in position for outside measurements, grasp the caliper with both hands, as shown in figure 3-17A, and adjust



4.17K
Figure 3-22.—Transferring a measurement from an outside to an inside caliper.



28.4A
Figure 3-23.—Caliper square (slide caliper).

both legs to the approximate setting. By adjusting both legs, the shape of the tool will be approximately symmetrical. Thus it will maintain its balance and be easier to handle.

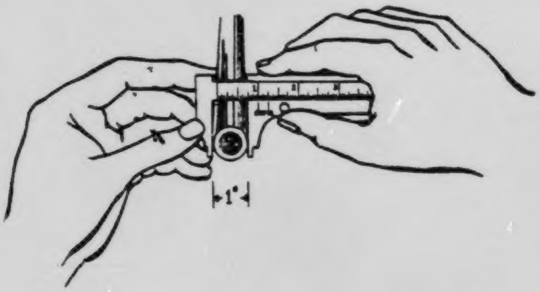
Check this approximate setting as shown in figure 3-17B. Sight squarely across the leg at the graduations on the rule to get the exact setting required.

If it is necessary to decrease or increase the setting, tap one leg of the caliper, as shown in figure 3-18. The arrow indicates the change in setting that will take place.

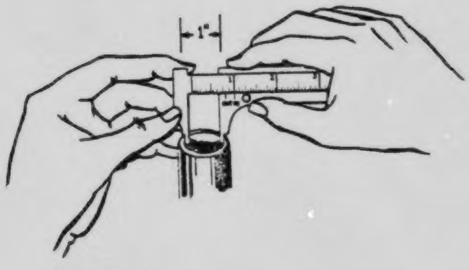
When the caliper is set for inside measurements, the same directions for adjusting the setting apply. Figure 3-19 shows how the end of the rule and one leg of the caliper are rested on the bench top so that they are exactly even with each other when the reading is taken.

Setting Outside And Inside Spring Calipers

To set a particular reading on an outside spring caliper, first open the caliper to the approximate setting. Then, as shown in figure 3-20, place one leg over the end of the rule, steadying it with index finger. Make the final setting by sighting over the other leg of the



44.71
Figure 3-24.—Measuring an outside dimension with a pocket slide caliper.



44.72
Figure 3-25.—Measuring an inside dimension with a slide caliper.

caliper, squarely with the face of the rule at the reading, and turning the knurled adjusting nut until the desired setting is obtained.

To set an inside spring caliper to a particular reading, place both caliper and rule on a flat surface as shown in figure 3-21. The rule must be held squarely or normal (90° in both directions) to the surface to ensure accuracy. Adjust the knurled adjusting nut, reading the setting on the rule with line of sight normal to the face of the rule at the reading.

Transferring Measurements From One Caliper To Another

To transfer a measurement from one spring caliper to another, hold the calipers as shown in figure 3-22. Note that one of the man's fingers is extended to steady the point of contact of the two lower caliper legs. In this figure the inside caliper is being adjusted to the size of the outside caliper. As careful measurements with calipers depend on one's sense of touch, which is spoken of as "feel," calipers are best held lightly. When you notice a slight drag, the caliper is at the proper setting.

CARE

Keep calipers clean and lightly oiled, but do not overoil the joint of firm joint calipers or you may have difficulty in keeping them tight. Do not throw them around or use them for screwdrivers or pry bars. Even a slight force may spring the legs of a caliper so that other measurements made with it are never accurate. Remember they are measuring instruments and must be used only for the purpose for which they are intended.

SLIDE CALIPER

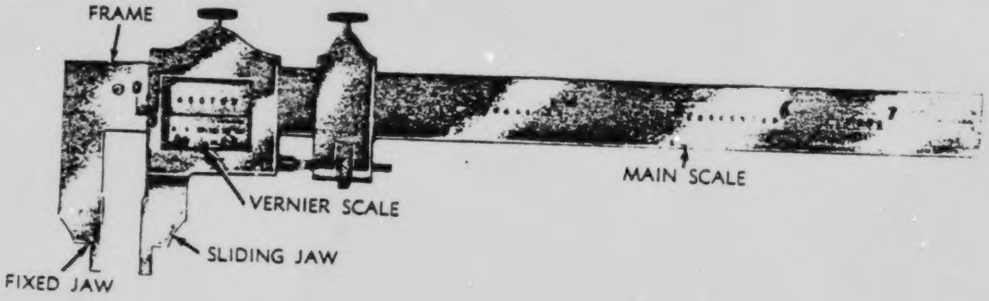
The main disadvantage of using ordinary calipers is that they do not give a direct reading of a caliper setting. As explained earlier, you must measure a caliper setting with a rule. To overcome this disadvantage, use slide calipers (fig. 3-23). This instrument is occasionally called a caliper rule.

Slide calipers can be used for measuring outside, inside, and other dimensions. One side of the caliper is used as a measuring rule, while the scale on the opposite side is used in measuring outside and inside dimensions. Graduations on both scales are in inches and fractions thereof. A locking screw is incorporated to hold the slide caliper jaws in position during use. Stamped on the frame are two words, "IN" and "OUT." These are used in reading the scale while making inside and outside measurements, respectively.

To measure the outside diameter of round stock, or the thickness of flat stock, move the jaws of the caliper into firm contact with the surface of the stock. Read the measurement at the reference line stamped OUT. (See fig. 3-24.)

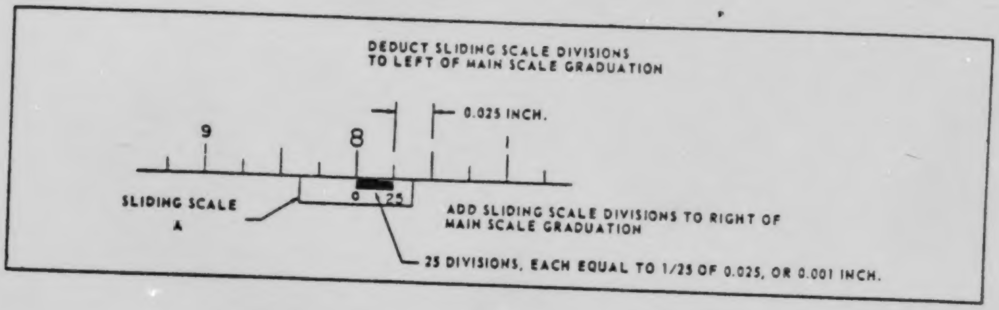
When measuring the inside diameter of a hole, or the distance between two surfaces, insert only the rounded tips of the caliper jaws into the hole or between the two surfaces. (See fig. 3-25.) Read the measurement on the reference line stamped IN.

Note that two reference lines are needed if the caliper is to measure both outside and inside dimensions, and that they are separated


FRAME
VERNIER SCALE
MAIN SCALE
SLIDING JAW
FIXED JAW

28.4B

Figure 3-26.—Vernier caliper.


DEDUCT SLIDING SCALE DIVISIONS TO LEFT OF MAIN SCALE GRADUATION
0.025 INCH.
9
8
1
SLIDING SCALE
A
0
25
ADD SLIDING SCALE DIVISIONS TO RIGHT OF MAIN SCALE GRADUATION
25 DIVISIONS, EACH EQUAL TO 1/25 OF 0.025, OR 0.001 INCH.

29.266A

Figure 3-27.—Vernier scale principle.

by an amount equal to the outside dimension of the rounded tips when the caliper is closed.

Pocket models of slide calipers are commonly made in 3-in. and 5-in. sizes and are graduated to read in 32nds and 64ths. Pocket slide calipers are valuable when extreme precision is not required. They are frequently used for duplicating work when the expense of fixed gages is not warranted.

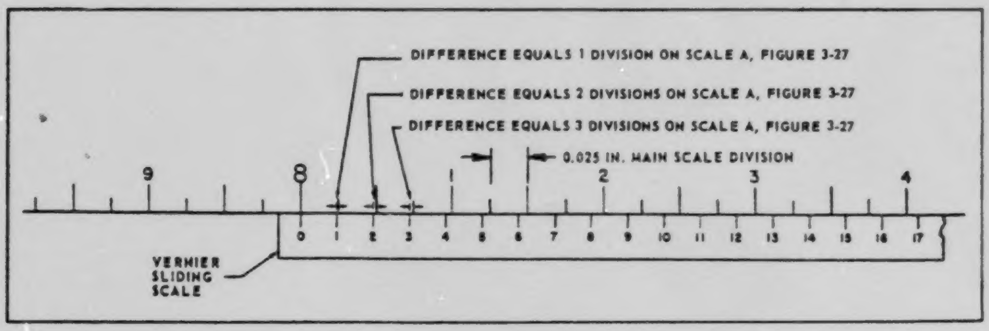
VERNIER CALIPER

A vernier caliper (fig. 3-26) consists of an L-shaped member with a scale engraved on the long shank. A sliding member is free to move on the bar and carries a jaw which matches the arm of the L. The vernier scale is engraved on a small plate that is attached to the sliding member.

Perhaps the most distinct advantage of the vernier caliper, over other types of caliper, is the ability to provide very accurate measurements over a large range. It can be used for both internal and external surfaces. Pocket models usually measure from zero to 3 in., but sizes are available all the way to 4 ft. In using the vernier caliper, you must be able to measure with a slide caliper and be able to read a vernier scale.

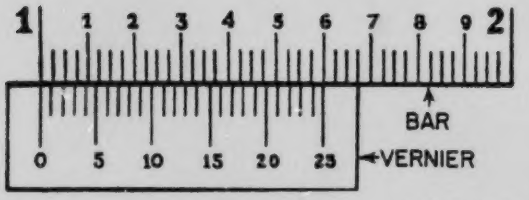
PRINCIPLES OF THE VERNIER SCALE

It would be possible to etch graduations 1/1000 inch (0.001) in. apart on a steel rule or sliding caliper as shown in figure 3-27. This enlarged illustration shows two graduated scales. The top scale has divisions which are 0.025 inches apart. The small sliding lower scale has 25 0.001 inch graduations which can divide any of the main scale divisions of 0.025 inch into 25 parts. When the first graduation marked "O" on this small scale aligns with a graduation on the main scale, the last, or 25th will also align with a graduation on the main scale as shown. Consequently, the small 0.00


DIFFERENCE EQUALS 1 DIVISION ON SCALE A, FIGURE 3-27
DIFFERENCE EQUALS 2 DIVISIONS ON SCALE A, FIGURE 3-27
DIFFERENCE EQUALS 3 DIVISIONS ON SCALE A, FIGURE 3-27
0.025 IN. MAIN SCALE DIVISION
9
8
1
2
3
4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
VERNIER SLIDING SCALE

29.266(44B)A

Figure 3-28.—Expanded view of the vernier scale.



29.266(44B)B

Figure 3-29.—English-measure vernier scale.

graduations are not significant in this position. But when the zero graduation does not align with a graduation on the main scale, it can be readily determined how many thousandths the zero missed the 0.025 inch graduation by counting the misaligned graduation at either end of the small scale. When the zero or index line on the sliding scale does not quite reach the graduation, the amount of misalignment must be subtracted, but when it passes the 0.025 graduation from which the reading is made, it must be added. This illustrates the simple arrangement to increase the accuracy of a common scale. Unfortunately, the 0.001 inch graduations are not too legible and so the system is not practical. A vernier arrangement overcomes this problem.

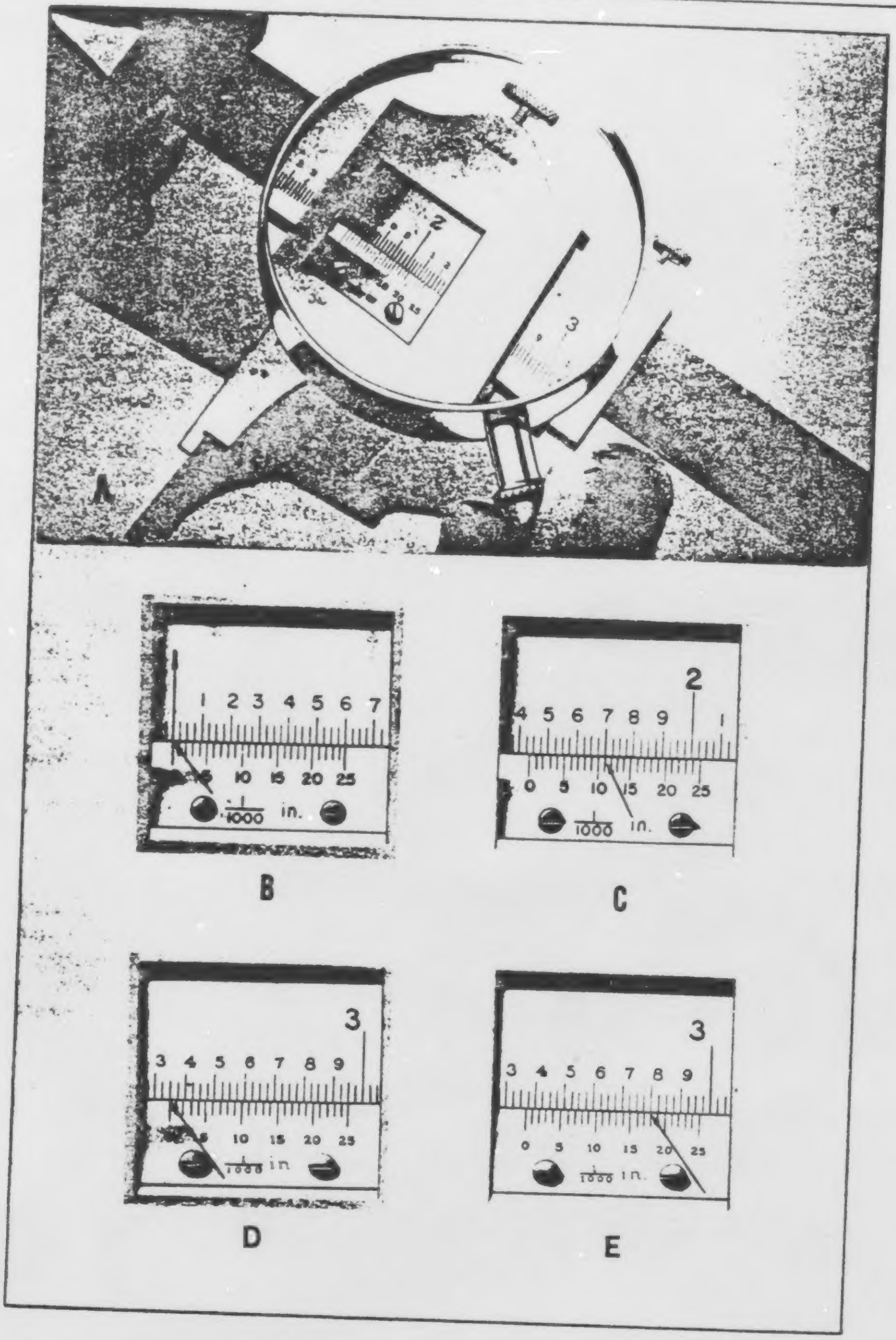
VERNIER SCALE ARRANGEMENT

The main difference between the vernier scale and the arrangement shown in fig. 3-27 is the spacing of the 25 divisions. Instead of 25 graduations crowded within the space of one main scale division, the vernier graduations are arranged at intervals exactly 0.001 inch less than the main scale graduations, as shown in fig. 3-28. This arrangement results in an accumulation of misalignments starting with the first vernier graduation past the zero so that each may be marked as shown with a number representing the space in thousandths to the next upper scale graduation. For example, if the zero index line would be moved past the 8 inch graduation until the vernier graduation number 5 aligned with the next main scale graduation, the exact reading would be 8 inches plus 0.005 or 8.005 inches.

READING A VERNIER CALIPER

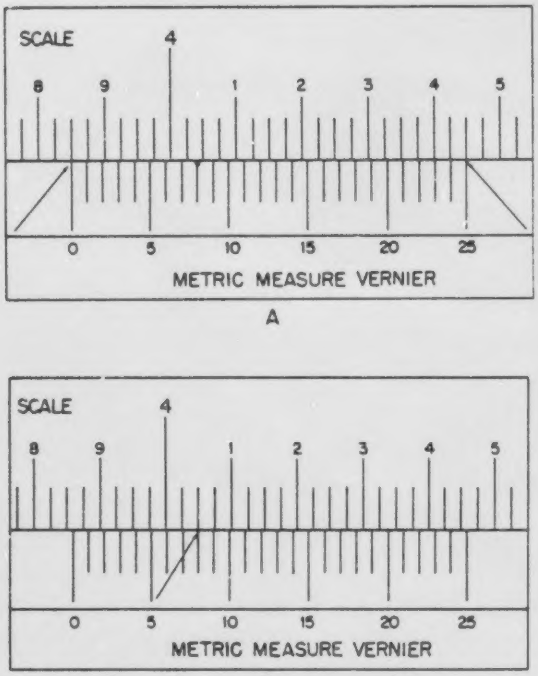
Figure 3-29 shows a bar 1 inch long divided by graduations into 40 parts so that each graduation indicates one-fortieth of an inch (0.025 inch). Every fourth graduation is numbered; each number indicates tenths of an inch (4 x 0.025 inch). The vernier, which slides along the bar, is graduated into 25 divisions which together, are as long as 24 divisions on the bar. Each division of the vernier is 0.001 inch smaller than each division on the bar. Verniers that are calibrated as just explained are known as English-measure verniers. The metric-measure vernier is read the same, except that the units of measurement are in millimeters.

In figure 3-30, insert A illustrates the English measure vernier caliper. Insert B shows an enlarged view of the vernier section. As you can see in this figure, when the zero on the vernier coincides with the 1-inch mark, no other lines coincide until the 25th mark on the vernier.


A
B
C
D
E
$\frac{1}{1000}$ in.

29.266B

Figure 3-30.—Vernier caliper.



A

B

29.266C

Figure 3-31.—Metric-measure vernier scales.

To read the caliper in insert C, write down in a column the number of inches (1.000 in.), of tenths of an inch (0.400 in.), and of thousandths of an inch that the zero mark on the vernier is from the zero mark on the rule. Because the zero mark on the vernier is a little past a 0.025 in. mark, write down the 0.025 in. and then note the highest number on the vernier where a line on the vernier coincides with one on the rule. In this case it is at the 0.011 in. line on the vernier, so you also write the 0.011 in. in the column which will then look like this:

$$\begin{array}{r} 1.000 \text{ in.} \\ .400 \text{ in.} \\ .025 \text{ in.} \\ \underline{.011 \text{ in.}} \\ 1.436 \text{ in.} \end{array}$$

The reading on the caliper shown in insert C is 1.436 in. and was obtained by adding four separate "readings." After a little practice you will be able to make these calculations mentally.

Table 3-1.—Measuring Point Allowances

44.216

Size of Caliper	English Measure	Metric Measure
6" or 150 mm .	Add 0.250"...	Add 6.35 mm.
12" or 300 mm .	.300"...	7.62 mm.
24" or 600 mm .	.300"...	7.62 mm.
36" or 600 mm .	.500"...	12.70 mm.

Now try to read the settings of the two verniers shown in inserts D and E. Follow the above procedure. You should read 2.350 in. on D and 2.368 in. on E.

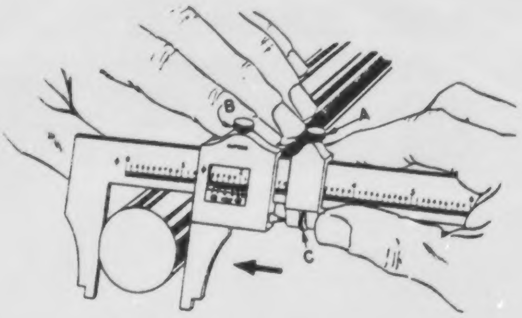
To read a metric-measure vernier, note the number of millimeters, and the 0.25 millimeter if the setting permits, that the zero on the vernier has moved from the zero on the scale. Then add the number of hundredths of a millimeter indicated by the line on the vernier that coincides with a line on the scale.

For example, figure 3-31A shows the zero graduation on the vernier coinciding with a 0.5-mm graduation on the scale resulting in a 38.50 mm reading. The reading in figure 3-31B indicates that 0.08 mm should be added to the scale reading and results in 38.00 mm + 0.50 mm + 0.08 mm = 38.58 mm.

If a vernier caliper is calibrated in either English measure or in metric measure, usually one side will be calibrated to take outside measurements and the other to take inside measurements directly. The vernier plate for inside measurements is set to compensate for the thickness of the measuring points of the tools. But if a vernier caliper is calibrated for both English and metric measure, one of the scales will appear on one side and one on the other. Then it will be necessary, when taking inside measurements over the measuring points, to add certain amounts to allow for their thickness. For example, table 3-1 shows the amounts to be added for various sizes of vernier calipers.

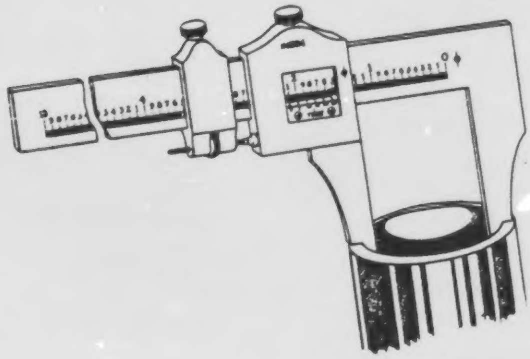
Outside Surface Measurements

To measure the distance between outside surfaces or the outside diameter of round stock with a vernier caliper, steady the stock with one hand and hold the caliper in the other as shown in figure 3-32. In the figure, the clamping



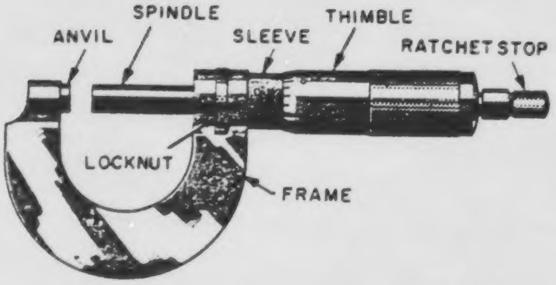
28.4C

Figure 3-32.—Measuring an outside diameter with a vernier caliper.



28.4D

Figure 3-33.—Measuring an inside diameter with a vernier caliper.



4.20.1A

Figure 3-34.—Nomenclature of an outside micrometer caliper.

screws are at A and B; the horizontal adjusting screw nut is at C. With A and B loose, slide the movable jaw toward the piece being measured until it is almost in contact. Then tighten A to make C operative. With C, adjust the movable jaw to the proper feel and secure the setting with B. The reading can then be taken as explained previously.

Inside Surface Measurements

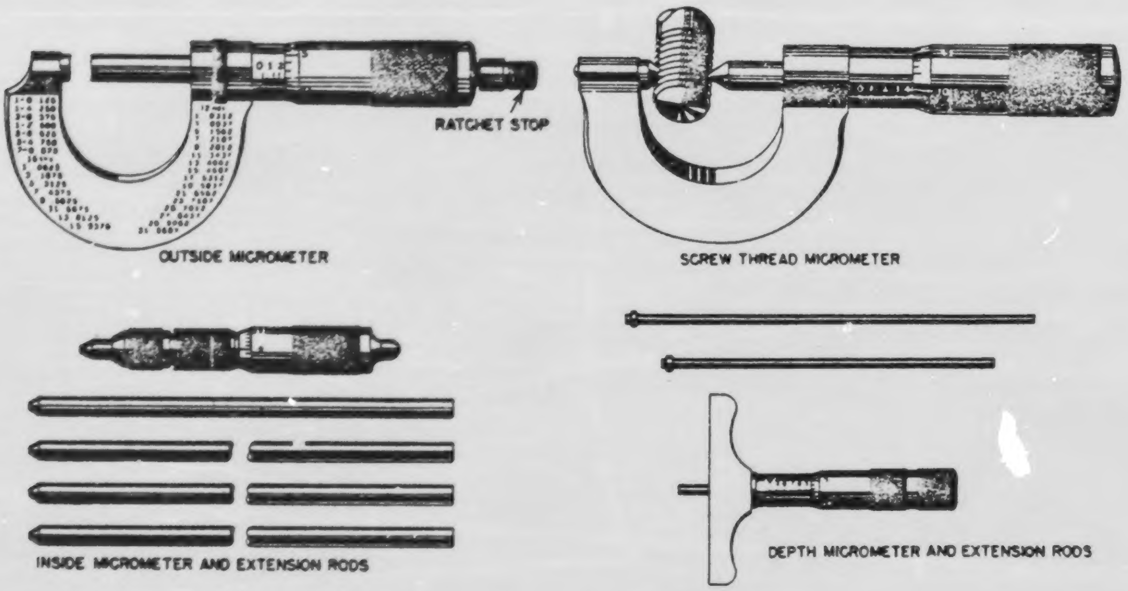
To measure the distance between inside surfaces, or the inside diameter of a hole, with a vernier caliper, use the scale marked "inside." Figure 3-33 shows the measuring points in place. Remember that if you are using a vernier caliper with both metric and English scales, the scales appear on opposite sides of the caliper and apply only to outside measurements. Then, to get correct inside measurements, you add to the actual reading the measuring point allowance for the size of caliper you are using. Take this allowance from table 3-1 or the manufacturer's instructions. The actual measurement in this case is made in the same manner as taking an outside measurement.

CARE OF THE VERNIER CALIPER

The inside faces of the jaws and the outside of the tips must be treated with great care. If they become worn, or the jaws bent, the tool will no longer give accurate readings. The accuracy of vernier calipers should be checked periodically by measuring an object of known dimension. Vernier calipers can be adjusted when they are not accurate, but the manufacturer's recommendations for this adjustment must be followed. Keep vernier calipers lightly oiled to prevent rust and keep them stored away from heavy tools.

MICROMETER

In much wider use than the vernier caliper is the micrometer commonly called the "mike." It is important that a person who is working with machinery or in a machine shop thoroughly understand the mechanical principles, construction, use, and care of the micrometer. Figure 3-34 shows an outside micrometer caliper with the various parts clearly indicated. Micrometers are used to measure distances to the nearest one thousandth of an inch. The measurement is usually expressed or written as a


RATCHET STOP
OUTSIDE MICROMETER
SCREW THREAD MICROMETER
INSIDE MICROMETER AND EXTENSION RODS
DEPTH MICROMETER AND EXTENSION RODS

4.20.1B

Figure 3-35.—Common types of micrometers.

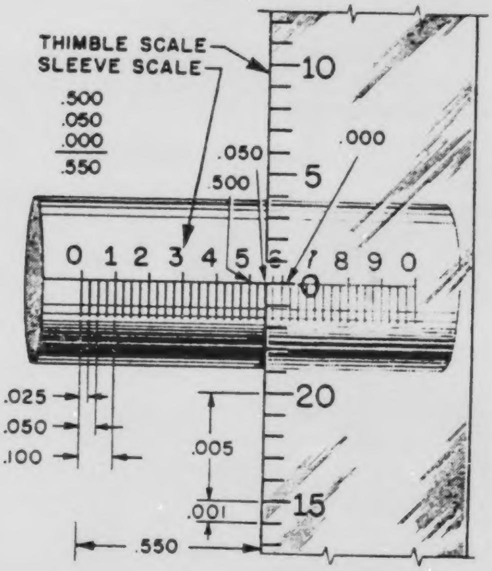
decimal; so you must know the method of writing and reading decimals.

TYPES

There are three types of micrometers that are most commonly used throughout the Navy: the outside micrometer caliper (including the screw thread micrometer), the inside micrometer, and the depth micrometer. (See fig. 3-35.) The outside micrometer is used for measuring outside dimensions, such as the diameter of a piece of round stock. The screw thread micrometer is used to determine the pitch diameter of screws. The inside micrometer is used for measuring inside dimensions, as for example, the inside diameter of a tube or hole, the bore of a cylinder, or the width of a recess. The depth micrometer is used for measuring the depth of holes or recesses.

SELECTING THE PROPER MICROMETER

The types of micrometers commonly used are made so that the longest movement possible between the spindle and the anvil is 1 inch. This movement is called the "range." The frames of micrometers, however, are available in a wide variety of sizes, from 1 inch up to as large as 24 inches. The range of a 1-inch micrometer is from 0 to 1 inch; in other words, it can be used on work where the part to be measured is 1 inch or less. A 2-inch micrometer has a range from 1 inch to 2 inches, and will measure only work between 1 and 2 inches thick; a 6-inch micrometer has a range from 5 to 6 inches, and will measure only work between 5 and 6 inches thick. It is necessary, therefore, that the mechanic in selecting a micrometer first find the approximate size of the work to the nearest inch, and then select a micrometer that will fit it. For example, to find the exact diameter of a piece of round stock; use a rule and find the approximate diameter of the stock. If it is found to be approximately 3 1/4 inches, a micrometer with a 3- to 4-inch range would be required to measure the exact diameter. Similarly, with inside and depth micrometers, rods of suitable lengths must be fitted into the tool to get the approximate dimension within an inch, after which the exact measurement is read by turning the thimble. The size of a micrometer indicates the size of the largest work it will measure.



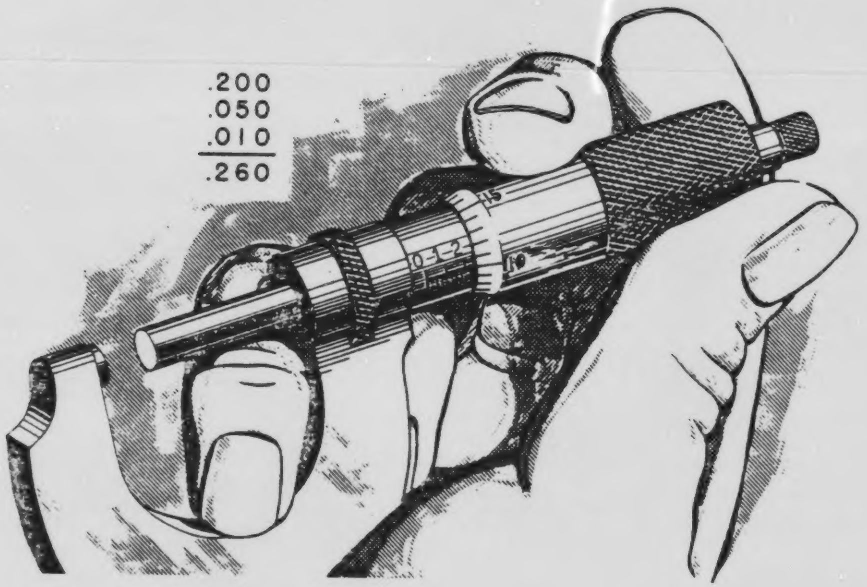
29.266D

Figure 3-36.—Sleeve and thimble scales of a micrometer (enlarged).

READING A MICROMETER CALIPER

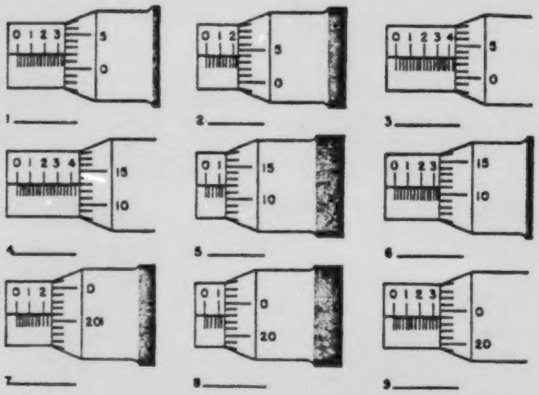
The sleeve and thimble scales of the micrometer caliper have been enlarged in figure 3-36. To understand these scales, you need to know that the threaded section on the spindle, which revolves, has 40 threads per inch. Therefore, every time the thimble completes a revolution, the spindle advances or recedes 1/40" (0.025").

Notice that the horizontal line on the sleeve is divided into 40 equal parts per inch. Every fourth graduation is numbered 1, 2, 3, 4, etc., representing 0.100", 0.200", etc. When you turn the thimble so that its edge is over the first sleeve line past the "0" on the thimble scale, the spindle has opened 0.025". If you turn the spindle to the second mark, it has moved 0.025" plus 0.025" or 0.050". You use the scale on the thimble to complete your reading when the edge of the thimble stops between graduated lines. This scale is divided into 25 equal parts, each part representing 1/25 of a turn. And 1/25 of 0.025" is 0.001". As you can see, every fifth line on the thimble scale is marked 5, 10, 15,



4.20.2

Figure 3-37.—Read a micrometer caliper.



Answers for checking—

1. = 0.327
2. = 0.229
3. = 0.428
4. = 0.438
5. = 0.137
6. = 0.336
7. = 0.246
8. = 0.148
9. = 0.349

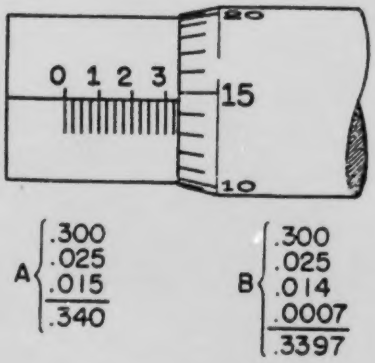
Figure 3-38.—Micrometer-reading exercises. 4.20

etc. The thimble scale, therefore, permits you to take very accurate readings to the thousandths of an inch, and, since you can estimate between the divisions on the thimble scale, fairly accurate readings to the ten thousandth of an inch are possible.

The closeup in figure 3-37 will help you understand how to take a complete micrometer reading. Count the units on the thimble scale and add them to the reading on the sleeve scale. The reading in the figure shows a sleeve reading of 0.250" (the thimble having stopped slightly more than halfway between 2 and 3 on the sleeve) with the 10th line on the thimble scale coinciding with the horizontal sleeve line. Number 10 on this scale means that the spindle has moved away from the anvil an additional 10 x 0.001" or 0.010". Add this amount to the 0.250" sleeve reading, and the total distance is 0.260".

Read each of the micrometer settings in figure 3-38 so that you can be sure of yourself when you begin to use this tool on the job. The correct readings are given following the figure so that you can check yourself.

Figure 3-39 shows a reading in which the horizontal line falls between two graduations on the thimble scale and is closer to the 15 graduation than it is to the 14. To read this to THREE decimal places, refer to figure 3-39 and calculation A. To read it to FOUR decimal places, estimate the number of tenths of the distance between thimble-scale graduations the horizontal line has fallen. Each tenth of this distance equals one ten-thousandth (0.0001) of an inch. Add the ten-thousandths to the reading as shown in the calculations of figure 3-39B.



29.266F

Figure 3-39.—Interpolating a micrometer reading.

READING A VERNIER MICROMETER CALIPER

Many times you will be required to work to exceptionally precise dimensions. Under these conditions it is better to use a micrometer that is accurate to ten-thousandths of an inch. This degree of accuracy is obtained by the addition of a vernier scale. This scale, shown in figure 3-40, furnishes the fine readings between the lines on the thimble rather than making you estimate. The 10 spaces on the vernier are equivalent to 9 spaces on the thimble. Therefore, each unit on the vernier scale is equal to 0.0009" and the difference between the sizes of the units on each scale is 0.0001".

When a line on the thimble scale does not coincide with the horizontal sleeve line, you can determine the additional space beyond the readable thimble mark by finding which vernier mark coincides with a line on the thimble scale. Add this number, as that many ten-thousandths of an inch, to the original reading. In figure 3-41 see how the second line on the vernier scale coincides with a line on the thimble scale.

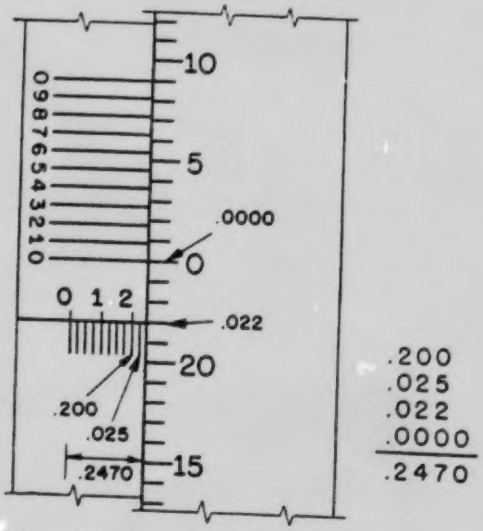
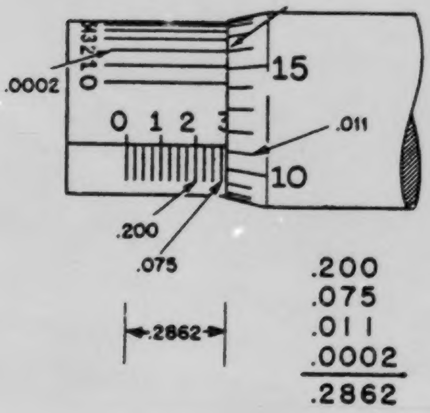
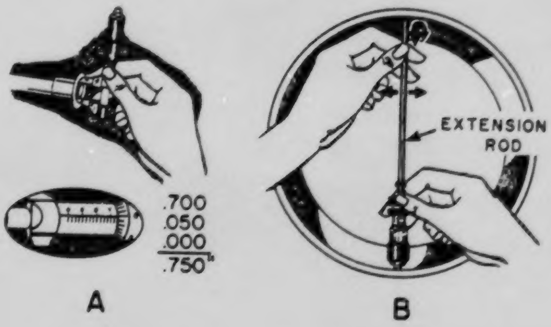

10
5
.0000
0
0 1 2
.022
20
.200
.025
.2470
15
.200
.025
.022
.0000
.2470

Figure 3-40.—Vernier scale on a micrometer. 29.266G

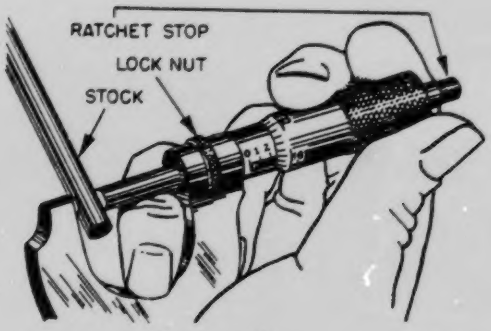

.0002
0 1 2 3
15
.011
10
.200
.075
.2862
.200
.075
.011
.0002
.2862

29.266H
Figure 3-41.—Read a vernier micrometer caliper.

This means that the 0.011 mark on the thimble scale has been advanced an additional 0.0002" beyond the horizontal sleeve line. When you add this to the other readings, the reading will be 0.200 + 0.075 + 0.011 + 0.0002 or 0.2862", as shown.


.700
.050
.000
.750"
EXTENSION ROD
A
B

44.77
Figure 3-42.—Measuring an inside diameter with an inside caliper.


RATCHET STOP
LOCK NUT
STOCK

4.20.2A
Figure 3-43.—Measuring round stock with a micrometer caliper.

MEASURING HOLE DIAMETERS WITH AN INSIDE MICROMETER CALIPER

To measure the diameter of small holes from 0.2" to 1" in diameter, an inside micrometer caliper of the jaw type as shown in figure 3-42A may be used. Note that the figures on both the thimble and the barrel are reversed, increasing in the opposite direction from those on an outside micrometer caliper. This is because this micrometer reads inside measurements. Thus as you turn the thimble clockwise on this micrometer, the measuring surfaces move farther apart and the reading increases. (On an outside micrometer caliper, as you turn the thimble clockwise, the measuring surfaces move closer together and the reading decreases.)

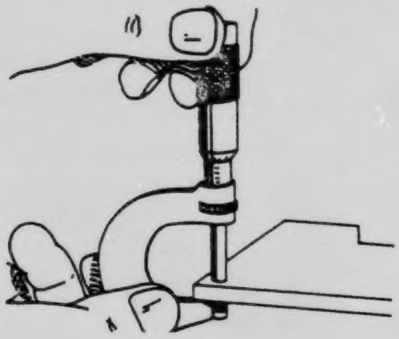


Figure 3-44.—Measuring flat stock with a micrometer caliper. 4.20.1C

For holes from 2" up to several feet in diameter, select the inside micrometer having extension rods whose range includes the required dimension. The extension rod marked "6-7," for example, when inserted into the head of the micrometer, will measure inside diameters from 6" to 7". The shoulder on the rod must seat properly to ensure a correct reading. Figure 3-42B shows that, for large measurements, both hands are used to set the micrometer for checking a diameter. Hole one end in place with one hand as you "feel" for the maximum possible setting by moving the other end from left to right, and in and out of the hole with the other hand. When no left-to-right movement is possible, and a slight drag is noticed on the in-and-out swing, take the reading.

MEASURING ROUND STOCK

When measuring the diameter of a small piece of round stock, hold the stock to be measured in one hand. Hold the micrometer in the other hand so that the thimble rests between the thumb and the forefinger. (See fig. 3-43.) The third finger is then in a position to hold the frame against the palm of the hand. The frame is supported in this manner and makes it easy to guide the work over the anvil. The thumb and forefinger are in position to turn the thimble either directly or through the ratchet and bring the spindle over against the surface being measured.

Turn the spindle down to contact by "feel," or else use the ratchet stop. Your feel should produce the same contact pressure and therefore the same reading as that produced when the ratchet stop is used. Develop your "feel" by measuring a certain dimension both with and without the aid of the ratchet stop. When you have the correct feel, you will get the same readings by both methods.

In measuring round stock the feel must be very light because there is only a line contact between the spindle and the stock and the anvil and the stock. Therefore the contact area is exceptionally small, causing a proportionally high contact pressure per unit of area. This tends to give a reading smaller than the true reading unless the light feel is used. Moreover, in measuring a ball from a ball bearing, the contact is at only two points, so the contact area is again very small, which results in a tremendous pressure per unit of area. This condition requires only the lightest possible contact pressure to give a true reading.

Hold the micrometer lightly and for only as long as is necessary to make the measurement. Wrapping the hand around it or holding it for too long a time will cause expansion of the metal and will introduce errors in measurement. Read the setting on the thimble scale (if the object is small) without removing the micrometer caliper from the object.

MEASURING A FLAT SURFACE

When measuring a flat surface with a micrometer caliper, the entire area of both the anvil and the spindle is in contact with the surface being measured. This causes a proportionally low contact pressure per unit of area. Therefore the "feel" should be slightly heavier than when measuring round stock.

On large flat work, it is necessary to have the work stationary and positioned to permit access for the micrometer. The proper method of holding a micrometer when checking a part too large to be held in one hand is shown in figure 3-44. The frame is held by one hand to position it and to locate it square to the measured surface. The other hand operates the thimble either directly or through the ratchet. A large flat surface should be measured in several places to determine the amount of variation. It is good practice to lock the spindle in place with the locknut before removing the micrometer from the part being measured. After removal of the micrometer the measurement indicated on the thimble scale can then be read.

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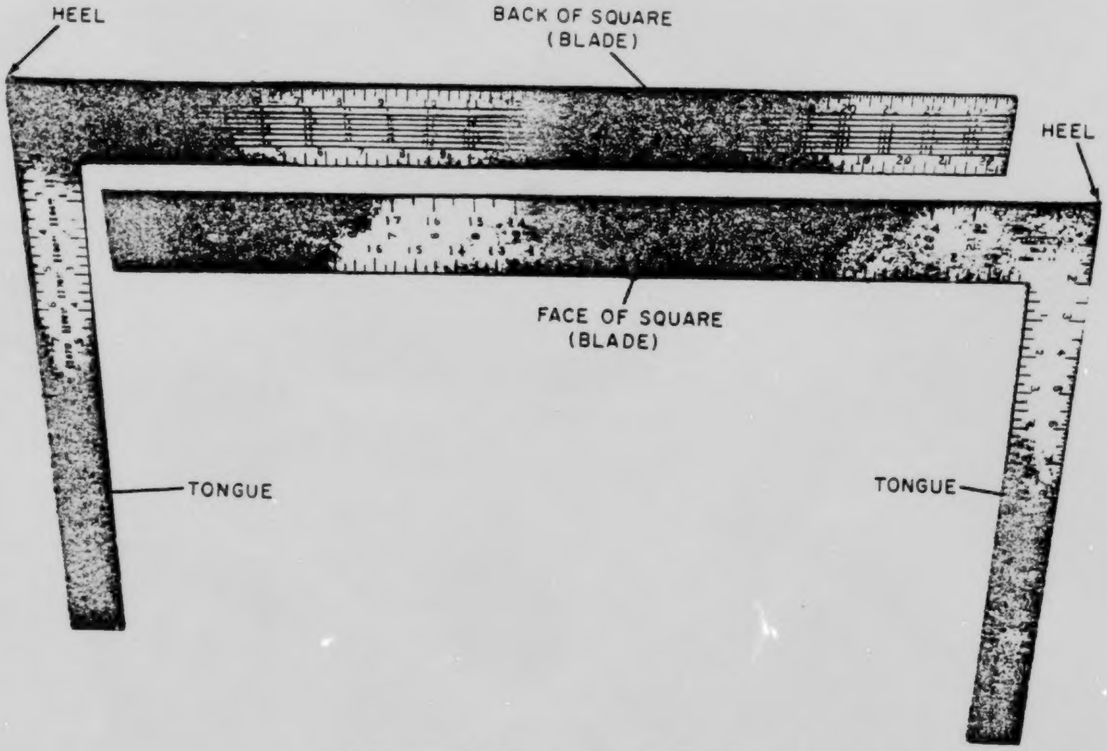


Figure 3-45.—Carpenter's square. 29.23A

To retain a particular setting, in cases where several pieces are to be gaged, lock the spindle in place with the locknut. When a piece is "gaged" with a micrometer whose spindle is locked to a particular setting, the piece can quickly be identified as oversize, correct size, or undersize.

CARE OF MICROMETERS

Keep micrometers clean and lightly oiled. Make sure they are placed in a case or box when they are not in use. Anvil faces must be protected from damage and must not be cleaned with emery cloth or other abrasive.

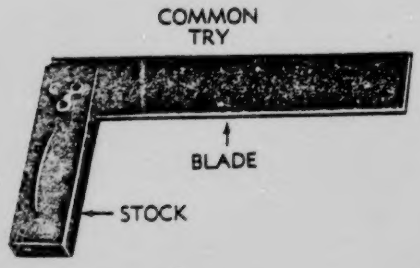
SQUARES

Squares are primarily used for testing and checking trueness of an angle or for laying out lines on materials. Most squares have a rule marked on their edge. As a result they may also be used for measuring. There are several types of squares commonly used in the Navy.

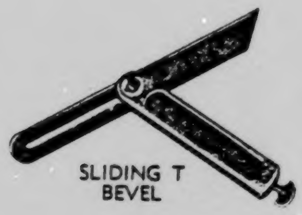
CARPENTER'S SQUARE

The size of a carpenter's steel square (fig. 3-45) is usually 12 inches x 8 inches, 24 inches x 16 inches, or 24 inches x 18 inches. The flat sides of the blade and the tongue are graduated in inches and fractions of an inch. (The square also contains information that helps to simplify or eliminate the need for computations in many woodworking tasks.) The most common uses for this square are laying out and squaring up large patterns, and for testing the flatness and squareness of large surfaces. Squaring is accomplished by placing the square at right angles to adjacent surfaces and observing if light shows between the work and the square.

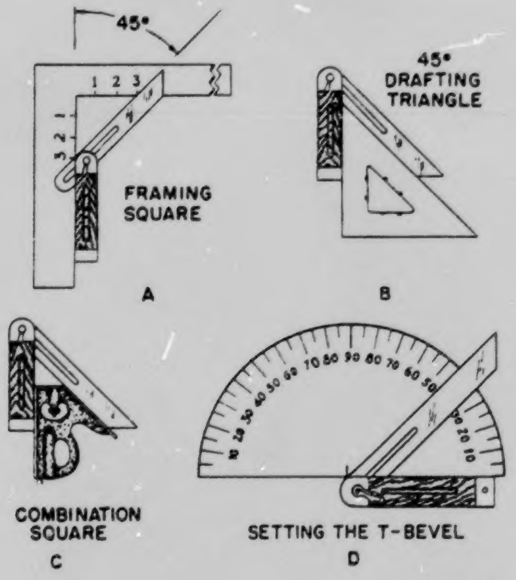
One type of carpenter's square (framing) has additional tables engraved on the square. With



44.25
Figure 3-46.—Common try square.



44.26
Figure 3-47.—Sliding T-bevel.



44.26A
Figure 3-48.—Adjusting a sliding T-bevel to a desired setting.

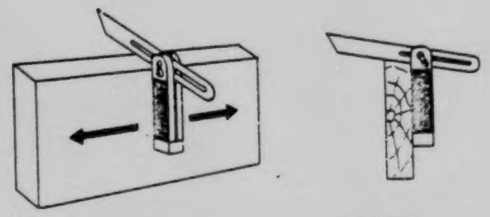
the framing square, the craftsman can perform calculations rapidly and layout rafters, oblique joints and stairs.

TRY SQUARE

The try square (fig. 3-46) consists of two parts at right angles to each other; a thick wood or iron stock and a thin, steel blade. Most try squares are made with the blades graduated in inches and fractions of an inch. The blade length varies from 2 inches to 12 inches. This square is used for setting or checking lines or surfaces which have to be at right angles to each other.

SLIDING T BEVEL

The sliding T-bevel (fig. 3-47) is an adjustable try square with a slotted beveled blade. Blades are normally 6 or 8 inches long. The sliding T-bevel is used for laying out angles other than right angles, and for testing constructed angles such as bevels. These squares are made with either wood or metal handles.



44.26B
Figure 3-49.—Testing the trueness of a bevel.

Adjustments

To adjust a sliding T-bevel to a desired setting, loosen the blade screw, at the round end of the handle, just enough to permit the blade to slide along its slot and to rotate with slight friction.

To set the blade at a 45° angle, hold the handle against a framing square, as shown in figure 3-48A, with the blade intersecting equal graduations on the tongue and blade of the square. Or: hold the bevel against the edges of

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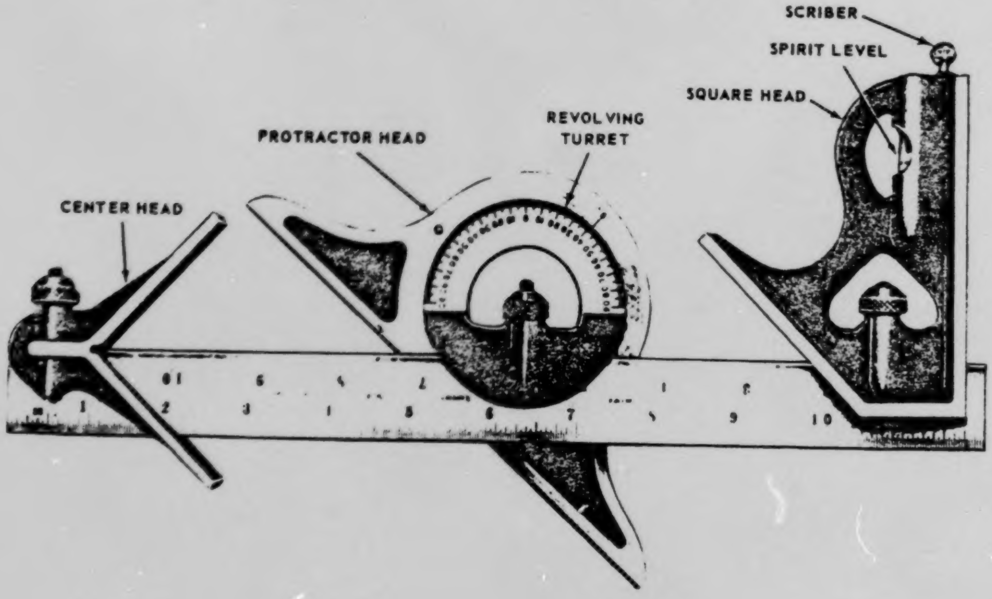


29.25

Figure 3-50.—Combination square set.

a 45° drafting triangle as shown in figure 3-48B. When using drafting triangles for setting a sliding T-bevel, different size triangles must be used for each different setting. A 45° angle can also be set by using the squaring head of a combination set as shown in figure 3-48C.

A sliding T-bevel can be set to any desired angle by using a protractor. Loosen the blade screw as before, and hold the bevel with its blade passing through the graduation selected, and the center of the protractor as shown at (D) in figure 3-48.

Constructed Angle Verification

To test a chamfer or bevel for trueness, set the T-bevel to the required angle, and hold the handle to the working face of the stock being tested. Face a source of light, and with the blade brought into contact with the surface to be tested, pass the blade along the length of the surface. (See fig. 3-49.) The appearance of light between the blade and the surface of the stock indicates where the angle is not correct. Figure 3-49 indicates the checking of a bevel, but testing the trueness of a chamfer is accomplished in the same way.

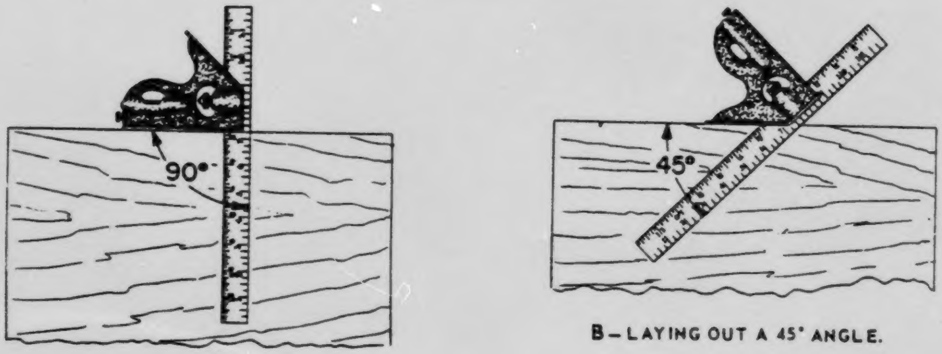
COMBINATION SQUARE

A combination square is equipped with movable heads called a SQUARE HEAD, PROTRACTOR HEAD, and a CENTER HEAD. These combine the functions of several tools, and serve a wide variety of purposes. (See figs. 3-50 and 3-51.) Normally, only one head is used at a time.

The SQUARE HEAD may be adjusted to any position along the scale and clamped securely in place. The combination square can thus serve as a depth gage, height gage, or scribing gage. Two of the faces of the head are ground at right angles to each other, and a third face at 45 degrees. A small spirit level is built into the head for checking whether surfaces are plumb, and a small scriber is housed in a hole in the end of the head for marking layout lines.

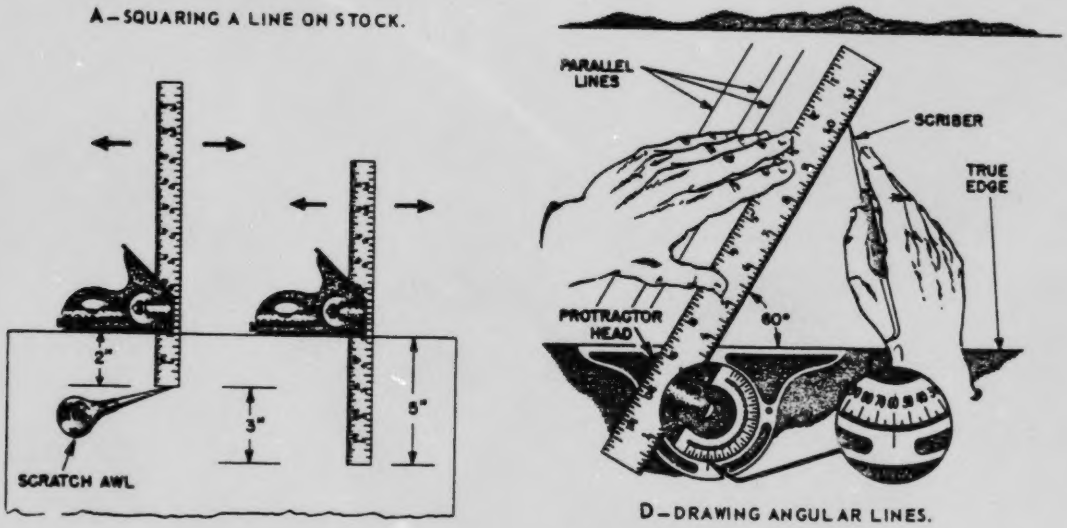
The CENTER HEAD can be slid on to the blade in place of the square head. This is a V-shaped member so designed that the center of the 90 degree V will lie exactly along one edge of the blade. This attachment is useful when locating the exact center of round stock.

The PROTRACTOR HEAD, commonly called a bevel protractor, can be attached to the scale,



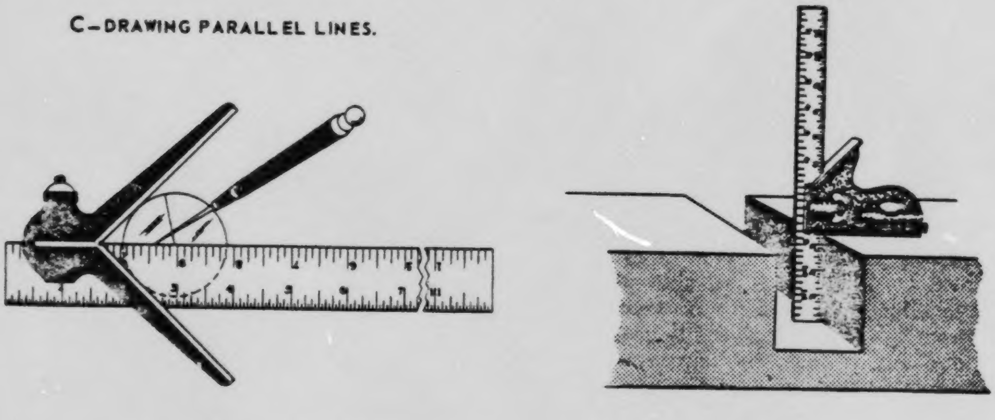
A—SQUARING A LINE ON STOCK.

B—LAYING OUT A 45° ANGLE.


2"
3"
5"
SCRATCH AWL
PARALLEL LINES
SCRIBER
TRUE EDGE
PROTRACTOR HEAD
60°

C—DRAWING PARALLEL LINES.

D—DRAWING ANGULAR LINES.



E—LOCATING A SHAFT CENTER.

F—MEASURING THE DEPTH OF A SLOT.

Figure 3-51.—Combination square applications.

44.73

718

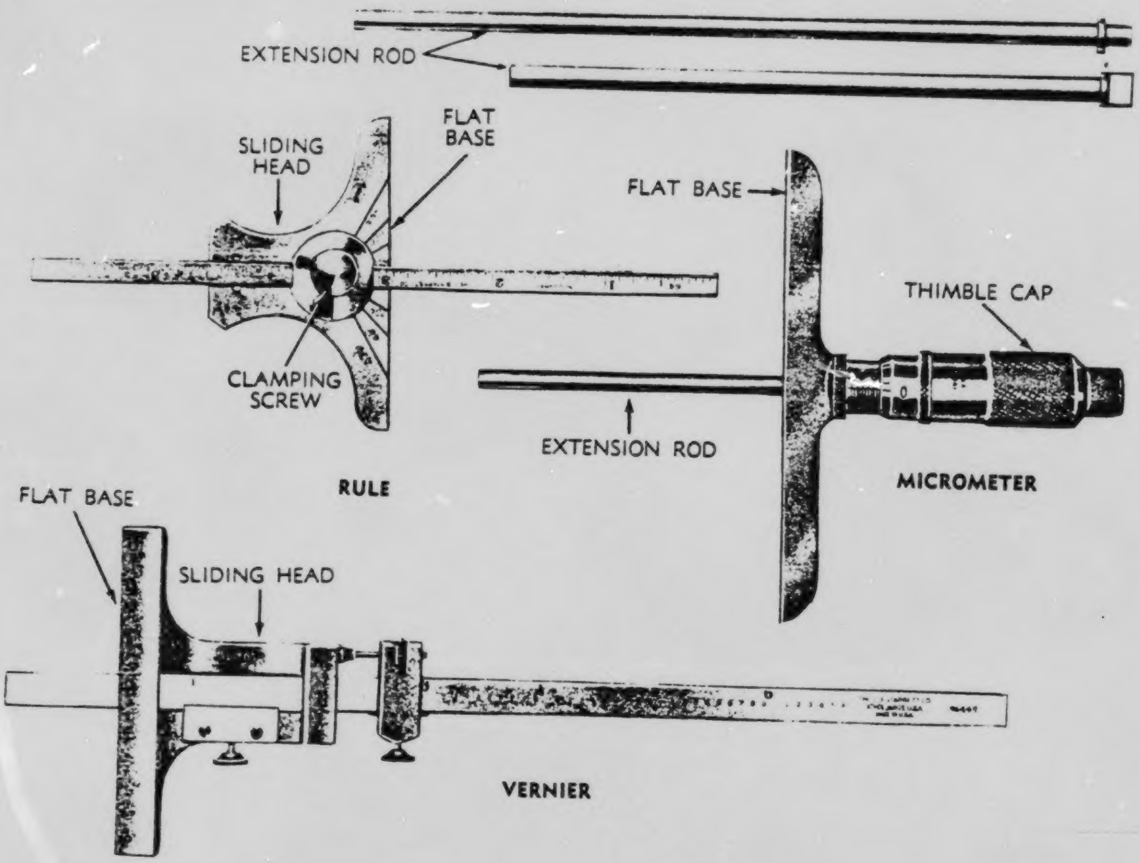

EXTENSION ROD
FLAT BASE
SLIDING HEAD
CLAMPING SCREW
RULE
FLAT BASE
THIMBLE CAP
EXTENSION ROD
MICROMETER
FLAT BASE
SLIDING HEAD
VERNIER

Figure 3-52.—Types of depth gages. 44.27

adjusted to any position on it, and turned and locked at any desired angle. Angular graduations usually read from 0 to 180 degrees both ways, permitting the supplement of the angle to be read. A spirit level may be included on some models forming, in effect, an adjustable level to show any required degree.

Care of Squares

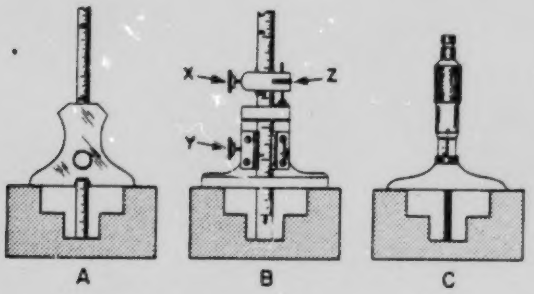
Make certain the blades, heads, dials, and all accessories are clean. Apply a light coat of oil on all metal surfaces to prevent rusting when not in use. Do not use squares for purposes other than those intended. When storing squares or bevels for long periods of time, apply a liberal amount of oil or rust-preventive compound to all surfaces, wrap in oiled paper or cloth, and place in containers or on racks away from other tools.

MISCELLANEOUS GAGES

There are a number of miscellaneous gages. The depth gage, feeler gage, thread gage, telescoping gage, dividers, and plumb bob are among some of the gages that will be discussed here.

DEPTH GAGE

A depth gage is an instrument for measuring the depth of holes, slots, counterbores, recesses,



44.74
Figure 3-53.—Using depth gages.

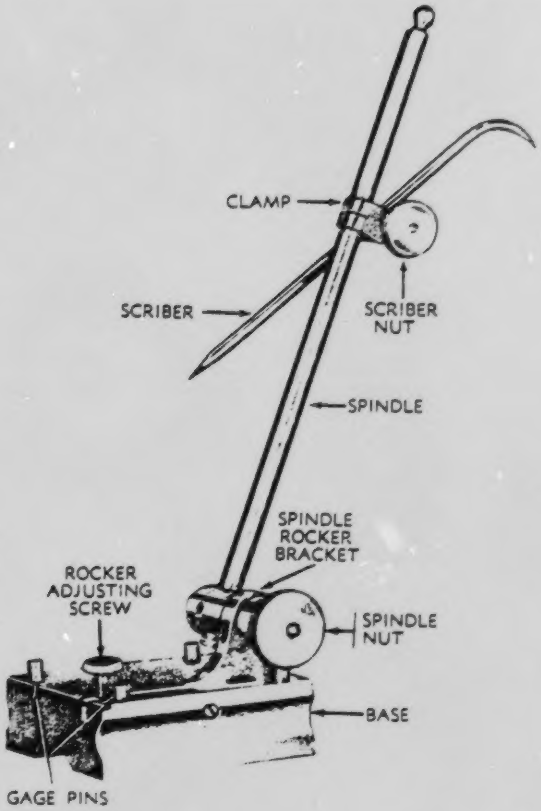
and the distance from a surface to some recessed part. The RULE DEPTH GAGE and the MICROMETER DEPTH GAGE are the most commonly used in the Navy. (See fig. 3-52.)

The rule depth gage is a graduated rule with a sliding head designed to bridge a hole or slot, and to hold the rule perpendicular to the surface on which the measurement is taken. This type has a measuring range of 0 to 5 inches. The sliding head has a clamping screw so that it may be clamped in any position. The sliding head has a flat base which is perpendicular to the axis of the rule and ranges in size from 2 to 2 5/8 inches in width and from 1/8 to 1/4 inch in thickness.

The micrometer depth gage consists of a flat base attached to the barrel (sleeve) of a micrometer head. These gages have a range from 0 to 9 inches, depending on the length of extension rod used. The hollow micrometer screw (the threads on which the thimble rotates) itself has a range of either 1/2 or 1 inch. Some are provided with a ratchet stop. The flat base ranges in size from 2 to 6 inches. Several extension rods are normally supplied with this type of gage.

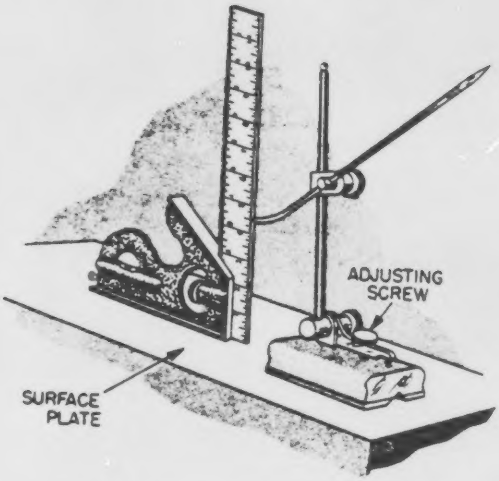
To measure the depth of a hole or slot with reasonable accuracy, use a depth gage as shown in figure 3-53A. Hold the body of the depth gage against the surface from which the depth is to be measured and extend the scale into the hole or slot. Tighten the setscrew to maintain the setting. Withdraw the tool from the work and read the depth on the scale.

To measure the depth of a hole or slot with more accuracy than is possible with an ordinary depth gage, place a vernier depth gage over the slot as shown in figure 3-53B. Notice the clamping screws are at X and Y; the horizontal adjusting screw nut is at Z. With X and Y loose, slide the scale down into the slot being measured until it is almost in contact. Then tighten X to make Z operative. With Z, adjust the scale to the "proper feel" and secure the setting with Y. By proper feel we mean the adjustment at which you first notice contact between the end of the scale and the bottom of the slot. Then read the setting as described under "Reading a vernier scale."



28.25.3
Figure 3-54.—Surface gage.

To set the vernier depth gage to a particular setting, loosen both setscrews at X and at Y and slide the scale through the gage to the approximate setting. Tighten the setscrew at X, turn the knurled nut at Z until the desired setting is made, and tighten the setscrew at Y to hold the setting.



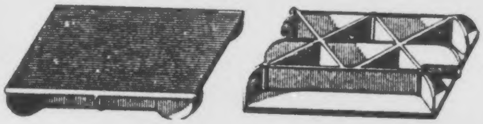
28.25
Figure 3-55.—Setting a surface gage to height.

To measure the depth of a hole or slot, as shown in figure 3-53C, with more accuracy than is possible with either an ordinary depth gage or a vernier depth gage, place a micrometer depth gage over the slot and adjust the thimble until the contact of the spindle causes the ratchet stop to slip. Remove the micrometer from the work and read the micrometer. Remember, if extension rods are used, the total depth reading will be the sum of the length of the rods plus the reading on the micrometer.

SURFACE GAGE

A surface gage is a measuring tool generally used to transfer measurements to work by scribing a line, and to indicate the accuracy or parallelism of surfaces.

The surface gage (fig. 3-54) consists of a base with an adjustable spindle to which may be clamped a scriber or an indicator. Surface gages are made in several sizes and are classified by the length of the spindle, the smallest spindle being 4 inches long, the average 9 or 12 inches long and the largest 18 inches. The scriber is fastened to the spindle with a clamp. The bottom and the front end of the base of the surface gage have deep V-grooves cut in them, which allow the gage to be seated on a cylindrical surface.



44.28
Figure 3-56.—Surface plate.

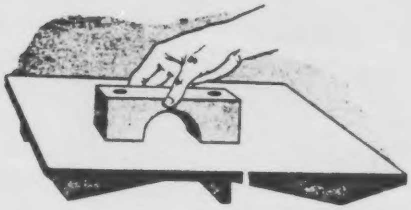
The spindle of a surface gage may be adjusted to any position with respect to the base and tightened in place with the spindle nut. The rocket adjusting screw provides for the finer adjustment of the spindle by pivoting the spindle rocker bracket. The scriber can be positioned at any height and in any desired direction on the spindle by tightening the scriber nut. The scriber may also be mounted directly in the spindle nut mounting, in place of the spindle, and used where the working space is limited and the height of the work is within range of the scriber.

To set a surface gage for height, first wipe off the top of a layout table or surface plate and the bottom of the surface gage. Use either a combination square or a rule with rule holder to get the measurement. A rule alone cannot be held securely without wobbling and consequently an error in setting generally results. Because a combination square is generally available, its use for setting a surface gage is explained in this section.

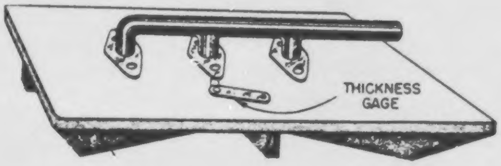
Place the squaring head of a combination square on a flat surface as shown in figure 3-55, and secure the scale so that the end is in contact with the surface. Move the surface gage into position and set the scriber to the approximate height required, using the adjusting clamp that holds the scriber onto the spindle. Make the final adjustment for the exact height required (4 1/2 inches in this case) with the adjusting screw on the base of the gage.

SURFACE PLATE

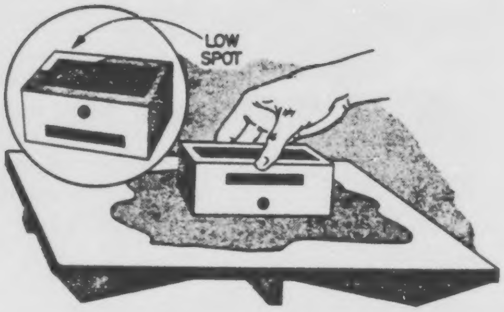
A surface plate provides a true, smooth, plane surface. It is a flat-topped steel or cast iron plate that is heavily ribbed and reinforced on the under side. (See fig. 3-56.) It is often used in conjunction with a surface gage as a level base on which the gage and part to be measured are placed to obtain accurate measurements. The surface plate can also be used for testing parts that must have flat surfaces.



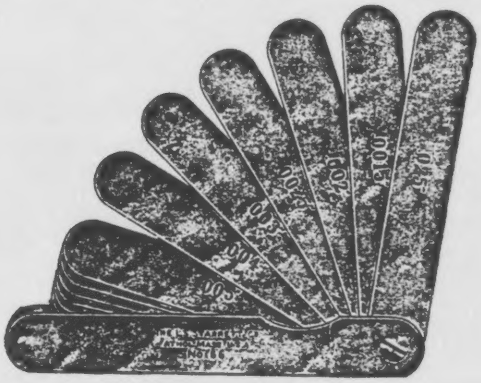
44.94
Figure 3-57.—Testing a surface for flatness.



44.95
Figure 3-59.—Checking the conformity of a flat surface.



28.33
Figure 3-58.—Using prussian blue to aid in testing a flat surface.



4.19
Figure 3-60.—Thickness gages.

To test a surface for flatness, carefully clean it and remove all burrs. Then place the surface of the object on a flat area such as the surface plate in figure 3-57. Any rocking motion that is apparent will indicate a variance from flatness of the piece being tested.

For very fine work, lightly coat the surface plate with prussian blue (bearing blue) and move the piece being tested across the blue surface. (See fig. 3-58.) The low spots on the surface being tested will not take the blue; the high spots will. See insert in figure 3-58.

To determine how much variation there is from flatness—and where it is—you can insert leaves of a thickness gage to determine the amount of variation of flatness. Remember to add the thickness of all leaves together to get the total variation. (See fig. 3-59.)

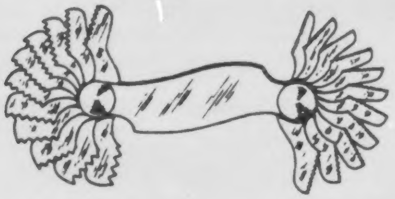
A surface also may be tested for flatness with a straightedge. To do this, clean the surface thoroughly and hold the straightedge on the surface in several places as you look toward a source of light. The light showing between the surface being tested and the straightedge will reveal the low spots.

Care of Surface Plates

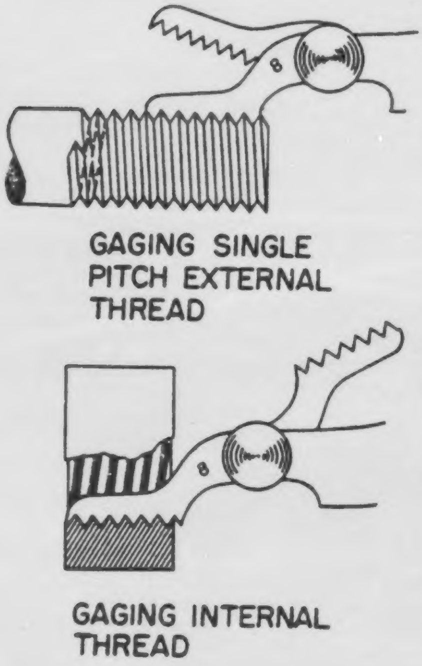
The surface plate should be covered when not in use to prevent scratching, nicking, and denting. It must be handled carefully to prevent warping (twisting). Never use the surface plate as an anvil or workbench—except for precision layout work (marking and measuring).

THICKNESS (FEELER) GAGE

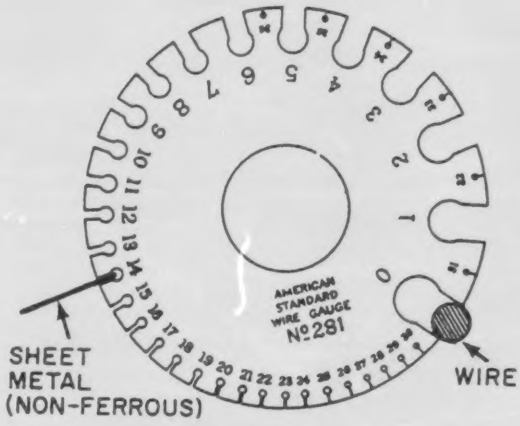
Thickness (feeler) gages are used for checking and measuring small openings such as contact point clearances, narrow slots, etc. These gages are made in many shapes and sizes and, as shown in figure 3-60, thickness gages can be made with multiple blades (usually 2 to 26). Each blade is a specific number of thousandths of an inch thick. This enables the application of one tool to the measurement of a variety of



5.14(44)
Figure 3-61.—Screw pitch gage.



28.153A
Figure 3-62.—Using a screw pitch gage.



5.15
Figure 3-63.—Using a wire gage to measure wire and sheet metal.

thicknesses. Some thickness gage blades are straight, while others are bent at 45 and 90 degree angles at the end. Thickness gages can also be grouped so that there are several short and several long blades together. Before using a feeler gage, remove any foreign matter from the blades. You cannot get a correct measurement unless the blades are clean.

When using a feeler gage consisting of a number of blades, insert various blades or combinations of blades between two surfaces until a snug fit is obtained. The thickness of the individual blade or the total thickness of ALL THE BLADES USED is the measurement between the surfaces.

Care of Thickness Gages

Handle the blades with care at all times. Keep from forcing the blades into openings that are too small for them. Some blades are very thin and can be bent or kinked easily. Blade edges and polished surfaces are also easy to damage. When not using a thickness gage, keep it closed.

THREAD GAGE

Thread gages (screw-pitch gages) are used to determine the pitch and number of threads per inch of threaded fasteners. (See fig. 3-61.) They consist of thin leaves whose edges are toothed to correspond to standard thread sections.

To measure the unknown pitch of a thread, compare it with the standards of the screw pitch gage. Hold a gage leaf to the thread being measured (fig. 3-62), substituting various sizes until you find an exact fit. Look at the fit toward a source of light for best results.

The number of threads per inch is indicated by the numerical value on the blade which is found to fit the unknown threads. Using this

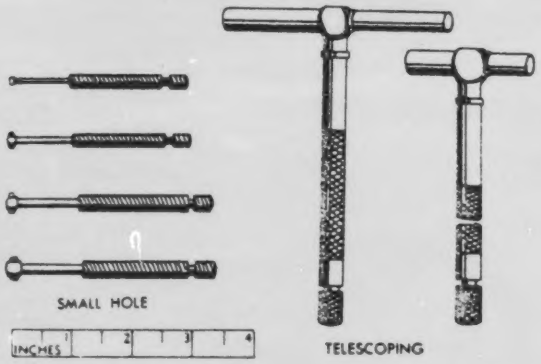
Table 3-2.—Wire and Sheet Metal Gages
44.203

Gage No.	Birmingham wire gage (B.W.G.) or Stubs iron wire gage, for iron wires, hot and cold rolled sheet steel	American wire gage, or Brown & Sharpe (for non-ferrous sheet and wire)	U.S. Standard gage for sheet and plate iron and steel	Steel wire gage, or the W & M (Washburn & Moen) for steel wire
0	.340	.3249	.3125	.3065
1	.300	.2893	.2812	.2830
2	.284	.2576	.2656	.2625
3	.259	.2294	.2500	.2437
4	.238	.2043	.2343	.2253
5	.220	.1819	.2187	.2070
6	.203	.1620	.2031	.1920
7	.180	.1443	.1876	.1770
8	.165	.1285	.1718	.1620
9	.148	.1144	.1562	.1483
10	.134	.1019	.1406	.1350
11	.120	.0907	.1250	.1205
12	.109	.0808	.1093	.1055
13	.095	.0719	.0937	.0915
14	.083	.0640	.0781	.0800
15	.072	.0570	.0703	.0720
16	.065	.0508	.0625	.0625
17	.058	.0452	.0562	.0540
18	.049	.0403	.0500	.0475
19	.042	.0359	.0437	.0410
20	.035	.0319	.0375	.0348
21	.032	.0284	.0343	.0317
22	.028	.0253	.0312	.0286
23	.025	.0225	.0281	.0258
24	.022	.0201	.0250	.0230
25	.020	.0179	.0218	.0204
26	.018	.0159	.0187	.0181
27	.016	.0142	.0171	.0173
28	.014	.0126	.0156	.0162
29	.013	.0112	.0140	.0150
30	.012	.0100	.0125	.0140
31	.010	.0089	.0109	.0132
32	.009	.0079	.0101	.0128
33	.008	.0071	.0093	.0118
34	.007	.0063	.0085	.0104
35	.005	.0056	.0078	.0095
36	.004	.0050	.0070	.0090

value as a basis, correct sizes of nuts, bolts, tap cutters, and die cutters are selected for use.

WIRE GAGE

The wire gage shown in fig. 3-63, is used for measuring the diameters of wires or the thickness of sheet metal. This gage is circular in shape with cutouts in the outer perimeter. Each cutout gages a different size from No. 0 to No. 36. Examination of the gage will show that the larger the gage number, the smaller the diameter or thickness.



44.29
Figure 3-64.—Small hole and telescoping gages.

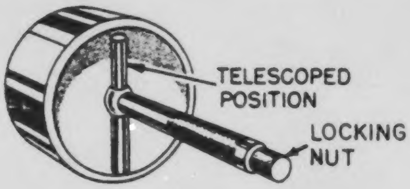
Gages similar to the one shown in figure 3-63 are available for measuring a variety of wires and sheet metals. The names of some common standard wire gages and their uses are given in the column headings of table 3-2. The body of this table contains gage numbers and their corresponding equivalents in decimal fractions of an inch.

Wire diameters may also be expressed in mils as well as by gage numbers. One mil equals one thousandth of an inch. Each decimal equivalent in table 3-2 can be converted to mils by multiplying by 1,000. For example, the circled decimal in the table is equivalent to .0640 x 1000 or 64 mils.

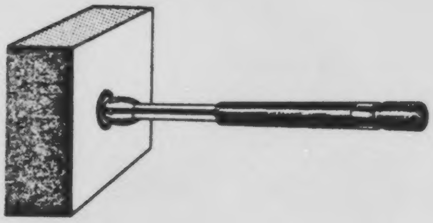
To use table 3-2, you select from the four gages listed in the table the one that applies to the sheet of metal or wire you want to gage. For instance, column 2 of the table tells you that the American Wire Gage shown in figure 3-63 is the one to use for nonferrous sheet or wire. Notice that each of the four gages has its own decimal equivalent for a particular gage number.

To measure wire size, apply the gage to the wire as shown in figure 3-63. Do not force the wire into the slot. Find the slot that refuses to pass the wire without forcing. Then, try the next larger slot until one is found that passes the wire. This is the correct size. Remember, your measurements are taken at the slot portion of the cutout rather than the inner portion of the gage. Now that you have the gage number turn your gage over and read the decimal equivalent for that number.

To measure the gage of a piece of metal, first remove any burr from the place where you



44.29.2
Figure 3-65.—Using a telescoping gage.



44.29.1
Figure 3-66.—Measuring the diameter of a hole with a small hole gage.

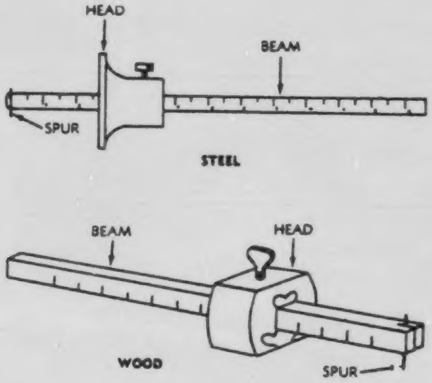
intend to apply the gage. Then select the appropriate gage for the metal to be measured.

After the right gage has been selected, apply the gage to the wire, or to the edge of the sheet as shown in figure 3-63. The number opposite the slot that fits the wire or sheet is its gage number. The decimal equivalent is stamped on the opposite face of the gage.

TELESCOPING GAGE

Telescoping gages are used for measuring the inside size of slots or holes up to 6 inches in width or diameter. They are T-shaped tools in which the shaft of the T is used as a handle, and the crossarm used for measuring. (See fig. 3-64.) The crossarms telescope into each other and are held out by a light spring. To use the gage the arms are compressed, placed in the hole to be measured, and allowed to expand. A twist of the locknut on top of the handle locks the arms. The tool may then be withdrawn and the distance across the arms measured.

These tools are commonly furnished in sets, the smallest gage for measuring the distances from 5/16 to 1/2 inch, and the largest for distances from 3 1/2 to 6 inches.



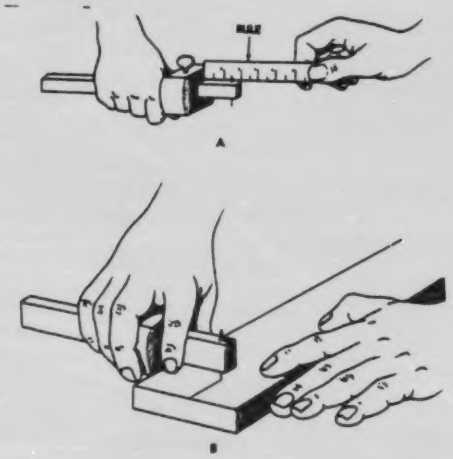
44.30
Figure 3-67.—Marking gages.

To measure the diameter of a hole from 1/2" to 6" in diameter, select from a set of telescoping gages the one whose range includes the size you need. Loosen the knurled nut at the end of the handle, and telescope the adjustable end of the gage to a size slightly smaller than the hole and retighten the nut. Insert the gage into the hole as shown in figure 3-65, loosen the nut to permit the spring-loaded adjustable end to expand to the hole diameter, and tighten the nut. The spring loaded contact of the adjustable end will assure proper contact. Make sure, however, that the gage is held with the telescoping end at right angles to the axis of the hole to measure the true, maximum diameter. Remove the gage and measure the setting with an outside micrometer caliper.

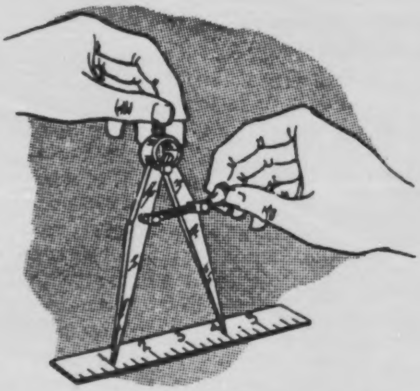
SMALL HOLE GAGE

For measuring smaller slots or holes than the telescoping gages will measure, small hole gages can be used. These gages come in sets of four or more and will measure distances of approximately 1/8 to 1/2 inch.

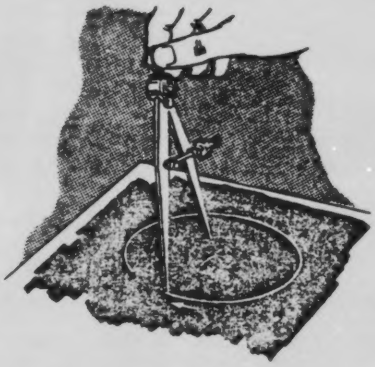
The small hole gage (fig. 3-64) consists of a small, split, ball-shaped member mounted on the end of a handle. The ball is expanded by turning a knurled knob on the handle until the proper feel is obtained (the slight drag of the ball end on the sides of the hole). The gage is then withdrawn (fig. 3-66) and the size of the ball-shaped member on the end of the gage can be measured with an outside micrometer caliper. On some types of small hole gages, the



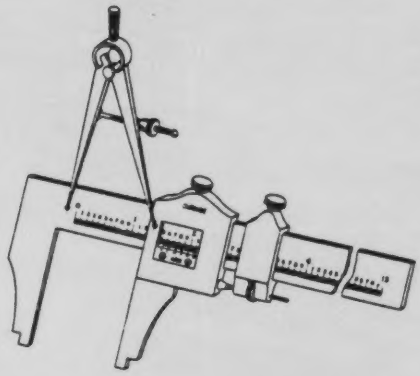
44.81
Figure 3-68.—Using the marking gage.



4.18
Figure 3-69.—Setting a divider to a desired radius.



28.22.1
Figure 3-70.—Scribing a circle with a divider.



28.4K
Figure 3-71.—Setting a divider with a vernier caliper.

the ball is flattened at the bottom near the centerline to permit use in shallow holes and recesses.

MARKING GAGES

A marking gage is used to mark off guidelines parallel to an edge, end, or surface of a piece of wood or metal. It has a sharp spur or pin that does the marking.

Marking gages (fig. 3-67) are made of wood or steel. They consist of a graduated beam about 8 inches long on which a head slides. The head can be fastened at any point on the beam by means of a thumbscrew. The thumbscrew presses a brass shoe tightly against the beam and locks it firmly in position. The steel pin or spur that does the marking projects from the beam about 1/16 inch.

To draw a line parallel to an edge with a marking gage, first determine the distance the line must be from the edge of the stock. Adjust the marking gage by setting the head the desired distance from the spur. Although the bar of a marking gage is graduated in inches, the spur may work loose or bend. If this occurs, accurate measurement should be made with a

726

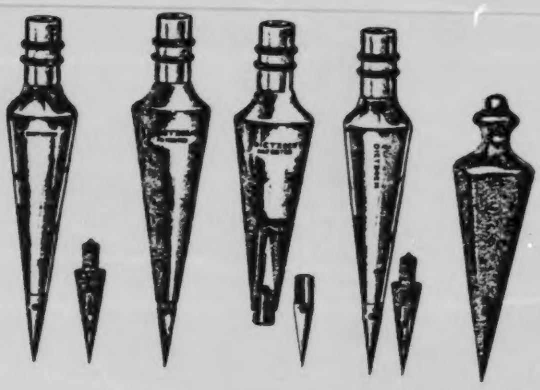


Figure 3-72.—Plumb bobs. 29.256AX

rule between the head and spur. (See fig. 3-68A.) To draw a line after setting the gage, grasp the head of the gage with the palm and fingers as shown in figure 3-68B; extend the thumb along the beam towards the spur. Press the head firmly against the edge of the work to be marked, and with a wrist motion tip the gage forward until the spur touches the work. Push the gage along the edge to mark the work, keeping the head firmly against the edge of the work.

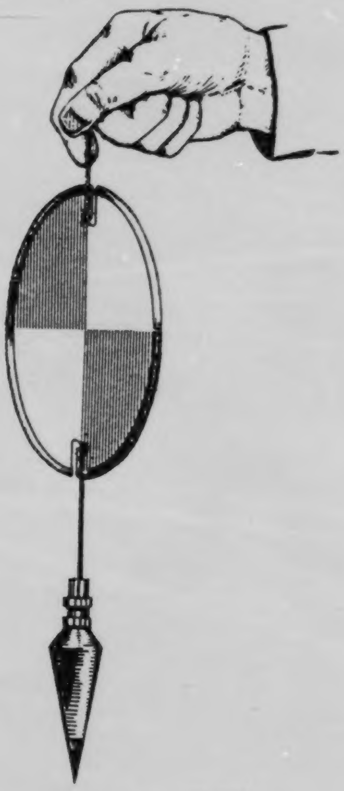
DIVIDERS

Dividers are useful instruments for transferring measurements and are frequently used in scribing arcs and circles in layout work.

To lay out a circle with a divider, set the divider at the desired radius, using a rule as shown in figure 3-69. Note that the 3-inch radius being set here is being taken at a central portion rather than at the end of the rule. This reduces the chance of error, as each point of the dividers can be set on a graduation.

Place one leg of the divider at the center of the proposed circle, lean the tool in the direction it will be rotated, and rotate it by rolling the knurled handle between your thumb and index finger (fig. 3-70).

Vernier calipers, which have two center points similar to prick punchmarks are particularly useful in setting a divider to exact dimensions. One center point will be found near the zero end of the scale on the rule. The other point is in line with the first and to the left of the zero on the vernier scale. (See fig. 3-71.)



29.258
Figure 3-73.—Plumb bob, cord, and target.

Set and secure the desired setting on the vernier caliper and adjust the divider until both points readily enter the center points on the vernier caliper as shown in figure 3-71.

PLUMB BOB

A plumb bob (fig. 3-72) is a pointed, tapered brass or bronze weight which is suspended from a cord for determining the vertical or plumb line to or from a point on the ground. Common weights for plumb bobs are 6, 8, 10, 12, 14, 16, 18, and 24 oz.

A plumb bob is a precision instrument and must be cared for as such. If the tip becomes bent, the cord from which the bob is suspended will not occupy the true plumb line over the point indicated by the tip. A plumb bob usually has a detachable tip, as shown in figure 3-72, so that if the tip should become damaged it can

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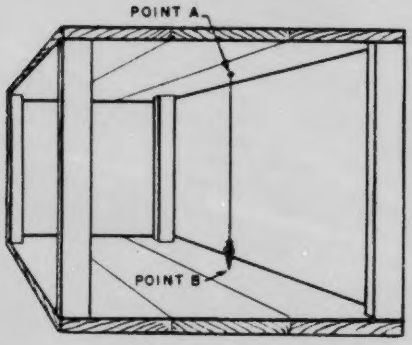
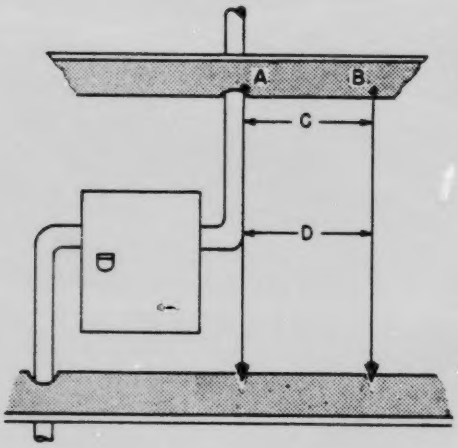


Figure 3-74.—Locating a point with a plumb bob. 44.91



44.92
Figure 3-75.—Plumbing a structural member with a plumb bob.

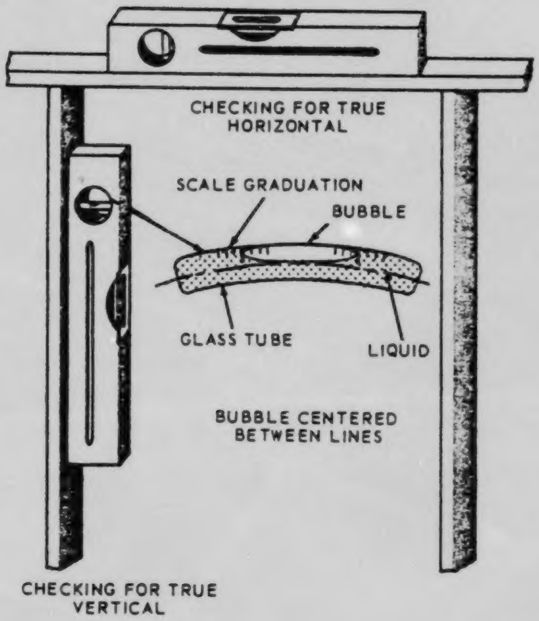

CHECKING FOR TRUE HORIZONTAL
SCALE GRADUATION
BUBBLE
GLASS TUBE
LIQUID
BUBBLE CENTERED BETWEEN LINES
CHECKING FOR TRUE VERTICAL

Figure 3-76.—Horizontal and vertical use of level. 29.13

be renewed without replacing the entire instrument.

The cord from a plumb bob can be made more conspicuous, for observation purposes, by attachment of a red-and-white target as shown in figure 3-73.

The plumb bob is used in carpentry to determine true verticality when erecting vertical uprights and corner posts of framework. Surveyors use it for transferring and lining up points.

To locate a point which is exactly below a particular point in space, when working ashore or on a ship in drydock, secure the plumb bob string to the upper point, such as A in figure 3-74. When the plumb stops swinging, the point as indicated at B in the illustration, will be exactly below A.

To plumb a structural member, or an electrical conduit, as shown by figure 3-75, secure the plumb line A so that you can look at both the line and piece behind the line. Then, by sighting, line up the member or conduit with the plumb line.

If this cannot be done, it may be necessary to secure the plumb line at some point such as B, and then measure the offset from the line to the piece at two places so that, for example, C and D in figure 3-75 are equal. If the distances between C and D are not equal, adjust the structural member or conduit until they are.

LEVELS

Levels are tools designed to prove whether a plane or surface is true horizontal or true vertical. Some precision levels are calibrated so that they will indicate in degrees, minutes, and seconds, the angle inclination of a surface in relation to a horizontal or vertical surface.

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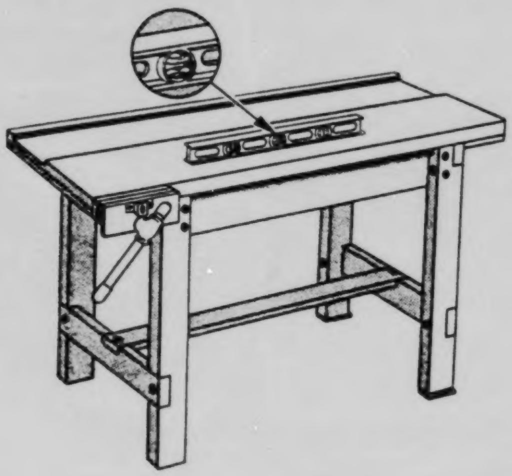
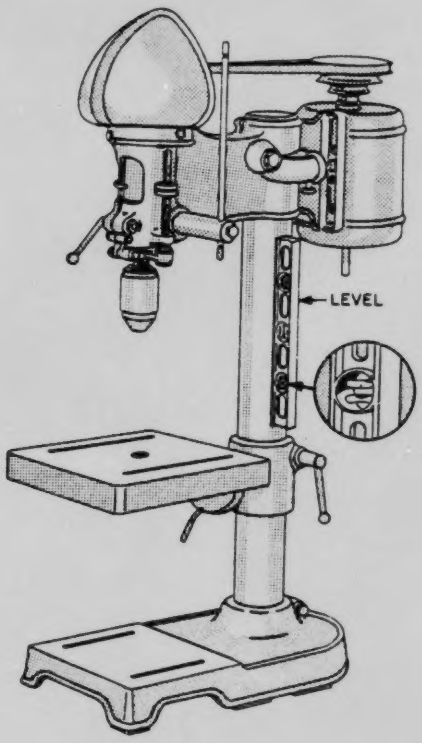


44.89
Figure 3-77.—Leveling a bench.

The level is a simple instrument consisting of a liquid, such as alcohol or chloroform, partially filling a glass vial or tube so that a bubble remains. The tube is mounted in a frame which may be aluminum, wood, or iron. Levels are equipped with one, two, or more tubes. One tube is built in the frame at right angles to another (fig. 3-76). The tube indicated in figure 3-76 is slightly curved, causing the bubble to seek always the highest point in the tube. On the outside of the tube are two sets of graduation lines separated by a space. Leveling is accomplished when the air bubble is centered between the graduation lines.

To level a piece of equipment, such as the workbench in figure 3-77, with a carpenter's level, set the level on the bench top parallel to the front edge of the bench. Notice that the level has several pairs of glass vials. Regardless of the position of the level, always watch the bubble in the bottom vial of a horizontal pair. Shim or wedge up the end of the bench that will return that bubble to the center of its vial. Recheck the first position of the level before securing the shims or wedges.



4.29
Figure 3-78.—Plumbing a piece of equipment with a level.

To plumb a piece of equipment, such as the drill press shown in figure 3-78, place the level on the side and on the front of the main column of the press. Figure 3-78 shows the level on the side. Use shims as necessary to bring the bubble in the lower vial of either pair of the horizontal vials to the center in each case.

Levels must be checked for accuracy. This is readily accomplished by placing the level on a true horizontal surface and noting the vial indication. Reverse the level end for end. If the bubble appears on one side of the graduations with reference to the operator on the first reading and on the other side for the second reading, the level is out of true and must be adjusted.

Do not drop or handle a level roughly. To prevent damage, store it in a rack or other suitable place when not in use.

CHAPTER 4

FASTENING COMPONENTS AND PROCEDURES

This chapter will discuss a variety of fastening devices and procedures so that you will be able to identify, select, and use the proper fasteners on specific jobs. Your knowledge of these fasteners will also enable you to perform assembly and disassembly work accurately, swiftly, and safely with proper tools. Furthermore, you will be able to minimize the effects of ship and aircraft vibration on these fasteners by using several safetying methods.

All fasteners are designed for one purpose—to attach components together securely. Some are used advantageously in woodworking. Others have special applications for fastening metal parts. Still others, are used to accelerate fastening and unfastening panels. Let's examine the distinctions between various kinds.

WOODWORKING FASTENERS

Before the development of nail-making, screw-making and bolt-making machinery, wooden members were held together by various types of interlocking joints that were reinforced with glue and wooden dowels. (A dowel is a cylindrical pin which is driven into a hole bored to receive it, and which serves much the same purpose as a nail.) Glued joints and joints fastened with wooden dowels are now confined mainly to furniture.

NAILS

Nails achieve their fastening or holding power when they displace wood fibers from their original position. The pressure exerted against the nail by these fibers, as they try to spring back to their original position, provides the holding power.

The usual type of shank is round, but there are various special-purpose nails with other types of shanks. Nails with square, triangular, longitudinally grooved and spirally grooved shanks have a much greater holding power than smooth round wire nails of the same size.

The lengths of the most commonly used nails are designated by the PENNY system. The abbreviation for the word "penny" is the letter "d." Thus the expression "a 2d nail" means a two-penny nail. The penny sizes and corresponding length, and thicknesses (in gage sizes) of the common nails are shown in table 4-1. The thickness of a nail increases and the number of nails per pound decreases with the penny size.

Nails larger than 20d are called spikes and are generally designated by their length in inches (such as 5 inches or 6 1/2 inches); nails smaller than 2d are designated in fractions of an inch instead of in the penny system.

Figure 4-1 shows the more common types of wire nails. The BRAD and the FINISH nail both have a deep countersink head that is designed to be "set" below the surface of the work. These nails are used for interior and exterior trimwork where the nails are "set" and puttied to conceal their location. The CASING nail is used for the same purpose, but because of its flat countersink head, may be driven flush and left that way.

The other nails shown in figure 4-1 are all flat-headed, without countersinks. One of these flat-headed nails (called the COMMON nail) is one of the most widely used in general wood construction. Nails with large flat heads are used for nailing roof paper, plaster board, and similar thin or soft materials. DUPLEX or DOUBLE-HEADED nails are used for nailing temporary structures, such as scaffolds, which are eventually to be dismantled. When using the double-headed nail it is driven to the lower head so that it can be easily drawn at a later time.

WOOD SCREWS

Screws have several advantages over nails. They may be easily withdrawn at any time without injury to the material. They also hold the wood more securely, can be easily tightened and, generally, are neater in appearance.

Wood screws are designated by material, type of head (fig. 4-2), and size.

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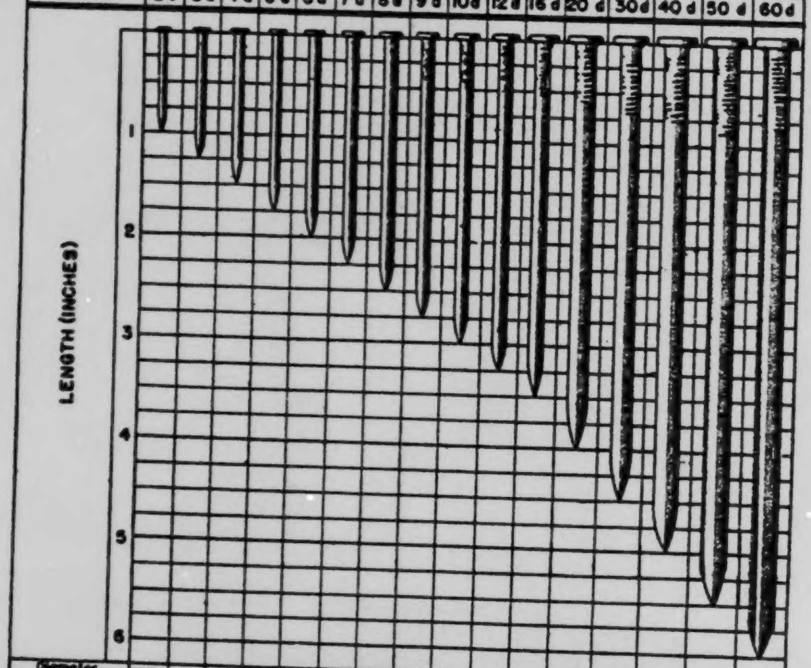
Table 4-1.—Common Nail Sizes

29.122



Size	2d	3d	4d	5d	6d	7d	8d	9d	10d	12d	16d	20d	30d	40d	50d	60d
Diameter (inches)	072	08	.098	.098	.113	.112	131	.131	.148	.148	.162	.192	.207	225	.244	.262
Steel wire gage	15	14	12	12	11	11	10	10	9	9	8	6	5	4	3	2
Number per pound	900	615	322	254	200	154	106	85	74	57	46	29	23	17	14	11

Most wood screws are made of steel or brass, but other metals are used as well. Cost or special purpose application will determine the selection of the material to be used.

The size of an ordinary wood screw is indicated by the length and body diameter (unthreaded part) of the screw. Figure 4-3 shows the nomenclature and the three most common types of wood screws. Notice that the length is always measured from the point to the greatest diameter of the head.

Body diameters are designated by gage numbers, running from 0 (for about a 1/16 in. diameter) to 24 (for about a 3/8-in. diameter).

Designation of length and gage number appear as "1 1/4-9". This means a No. 9 screw 1 1/4 inches long.

As a general rule, the length of a screw for holding two pieces of wood together should be such that the body extends through the piece being screwed down so the threaded portion will then enter the other piece. The wood screw simply passes through the hole in the top piece and the threads take hold in the bottom piece. See figure 4-4.

BOLTS

A bolt is distinguished from a wood screw by the fact that it does not thread into the wood, but goes through and is held by a nut threaded onto the end of the bolt. Figure 4-5 shows the four common types of bolts used in woodworking. STOVE bolts are rather small, ranging in length from 3/8 in. to 4 in., and in body diameter from 1/8 in. to 3/8 in. CARRIAGE AND MACHINE bolts run from 3/4 in. to 20 in. long, and from 3/16 in. to 3/4 in. in diameter. (The carriage bolt has a square section below the head, which is imbedded in the wood to prevent the bolt from turning as the nut is drawn up.) The machine bolt has a hexagon or square head which is held with a wrench to prevent it from turning.

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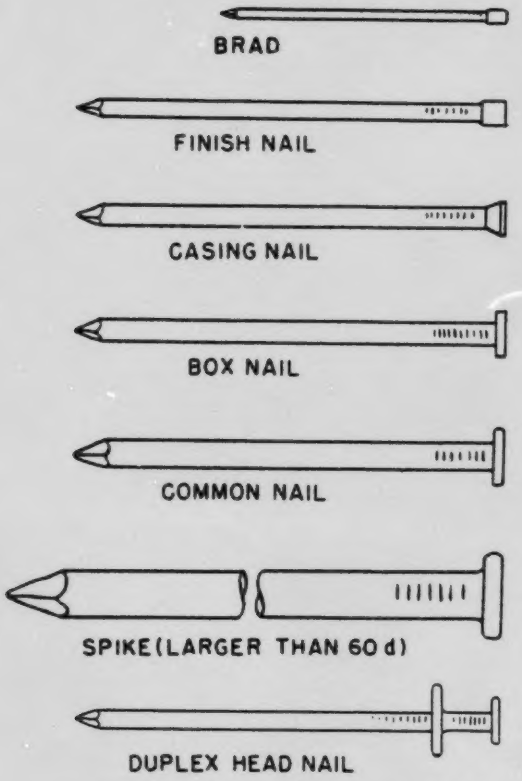
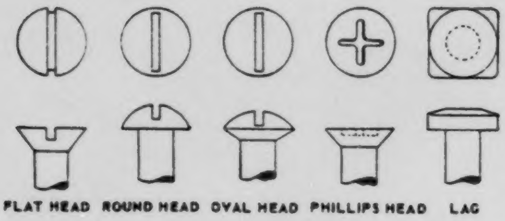
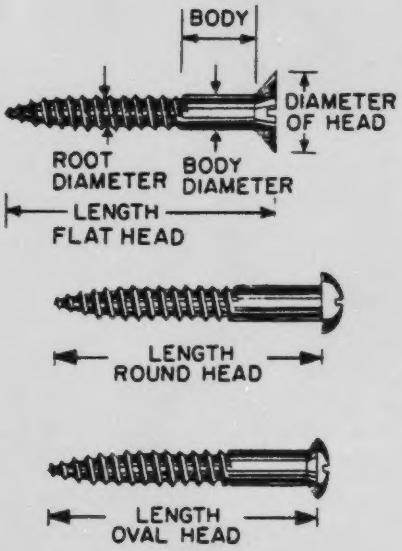

BRAD
FINISH NAIL
CASING NAIL
BOX NAIL
COMMON NAIL
SPIKE(LARGER THAN 60 d)
DUPLEX HEAD NAIL

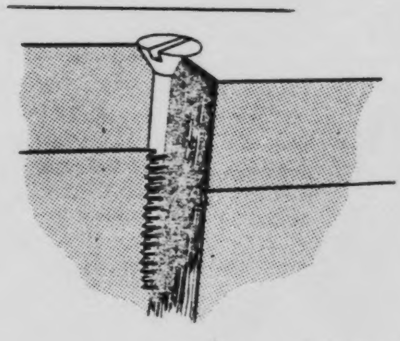
29.121A
Figure 4-1.—Nail varieties.


FLAT HEAD
ROUND HEAD
OVAL HEAD
PHILLIPS HEAD
LAG

29.123A
Figure 4-2.—Woodscrew heads.


BODY
DIAMETER OF HEAD
ROOT DIAMETER
BODY DIAMETER
LENGTH
FLAT HEAD
LENGTH
ROUND HEAD
LENGTH
OVAL HEAD

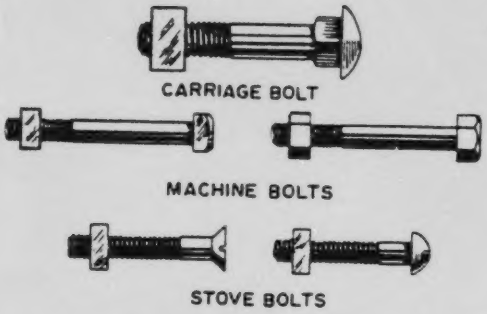
29.123JH
Figure 4-3.—Nomenclature and types of woodscrews.



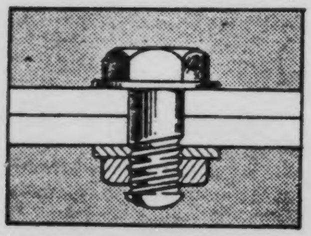
29.123G
Figure 4-4.—Using a woodscrew to hold two pieces of wood together.

METAL FASTENING DEVICES

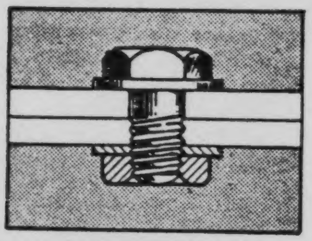
Many mechanisms and devices are held together with metal fasteners. Only the more commonly used fasteners will be discussed here so you will know when, where, and how they should be used. For example, if a flat point setscrew is used when specifications called for a cone point an important installation might fail at a crucial moment.



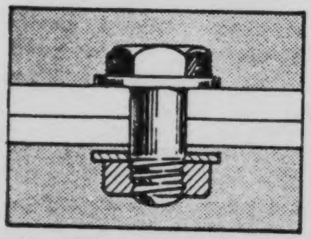
29.124X
Figure 4-5.—Bolts.



A BOLT GRIP LENGTH CORRECT



B BOLT GRIP LENGTH TOO SHORT



C BOLT GRIP LENGTH TOO LONG

29.124(44B)
Figure 4-6.—Correct and incorrect grip lengths.

Table 4-2.—Screw Threads per Inch
44.217

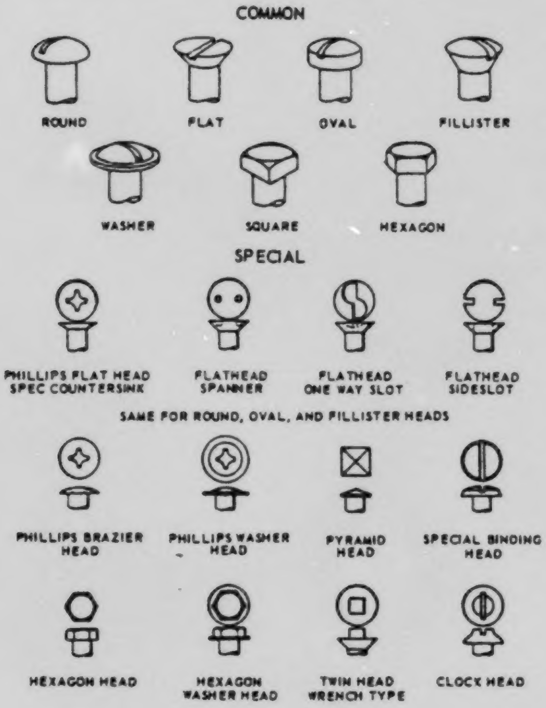
Diameter		Threads Per Inch			
No.	Inch	Decimal Equivalent	NC	NF	EF
0	----	.0600	---	80	---
1	----	.0730	64	72	---
2	----	.0860	56	64	---
3	----	.0990	48	56	---
4	----	.1120	40	48	---
5	----	.1250	40	44	---
6	----	.1380	32	40	---
8	----	.1640	32	36	---
10	----	.1900	24	32	40
12	----	.2160	24	28	---
---	1/4	.2500	20	28	36
---	5/16	.3125	18	24	32
---	3/8	.3750	16	24	32
---	7/16	.4375	14	20	28
---	1/2	.5000	13	20	28
---	9/16	.5625	12	18	24
---	5/8	.6250	11	18	24
---	3/4	.7500	10	16	20
---	7/8	.8750	9	14	20
---	1	1.0000	8	14	20

Metal parts can be fastened together with various fastening devices, such as rivets, bolts, screws, etc. Rivets provide a more permanent type of fastening whereas bolts and screws are used to fasten together parts that may have to be taken apart later.

BOLTS

When installing bolts, always be certain to install the bolt with its head in the direction of flight (in aircraft) or whenever possible, install it with the head UP. This way, if the nut has been improperly secured or is shaken loose by vibration and falls off, the bolt will remain within the part and continue to retain its holding capability although the nut is missing.

Be certain that the grip length of the bolt is correct. The grip length is the length of the unthreaded portion of the bolt shank. Generally speaking, the grip length should equal the thickness of the material which is being bolted together. Not more than ONE thread should bear on the material, and the threaded portion of the


COMMON
ROUND
FLAT
OVAL
FILLISTER
WASHER
SQUARE
HEXAGON
SPECIAL
PHILLIPS FLAT HEAD SPEC COUNTERSINK
FLATHEAD SPANNER
FLATHEAD ONE WAY SLOT
FLATHEAD SIDESLOT
SAME FOR ROUND, OVAL, AND FILLISTER HEADS
PHILLIPS BRAZIER HEAD
PHILLIPS WASHER HEAD
PYRAMID HEAD
SPECIAL BINDING HEAD
HEXAGON HEAD
HEXAGON WASHER HEAD
TWIN HEAD WRENCH TYPE
CLOCK HEAD

29.123(44B)

Figure 4-7.—Machine screw and capscrew heads.

shank should be showing through the nut. (See fig. 4-6A). In figure 4-6B no threads from the bolt shank show through the nut extremity and too many threads are bearing on the material. In figure 4-6C the nut can't be threaded far enough to apply pressure on the material.

Proper selection of bolt material is very important. It might even be VITAL. BE SURE, when required to replace bolts (or any type of fastener) you select the type of material designed for the equipment. For instance, suppose a stainless steel bolt were replaced by an iron bolt in a high pressure system aboard a submarine. Fast erosion and galvanic action could cause the bolt to fail and result in an explosion. Replace a bolt with one that has an identical part number only, or refer to bolt identification charts if the number is missing.

MACHINE SCREWS

The term "machine screw" is the general term used to designate the small screws that are used in tapped holes for the assembly of metal parts. Machine screws may also be used with nuts, but usually, they are screwed into holes that have been tapped with matching threads.

Machine screws are manufactured in a variety of lengths, diameters, pitches (threads per inch), materials, head shapes, finishes and thread fits. A complete description of machine screws must include these factors. For example, "1/2 inch, 8-32, round head, brass, chromium-plated, machine screw." The first number is the length of the screw. Let's examine some of these other factors.

Diameter and Pitch

The diameters of American Standard machine screws are expressed in gage numbers or fractions of an inch as shown in table 4-2. In the preceding paragraph, the "8-32" means that the screw gage is No. 8 and that it has 32 threads per inch. Note, particularly, that the "eight" and "thirty-two" are two separate numbers, indicating two individual measurements; they are never to be pronounced "six-thirty-seconds" or written as a fraction such as 6/32.

Materials and Finishes

Most machine screws are made of steel or brass. They may be plated to help prevent corrosion. Other special machine screws made of aluminum or Monel metal are also obtainable. The latter metal is highly resistant to the corrosive action of salt water.

Head Shapes

A variety of common and special machine screw head shapes are shown in figure 4-7. Some of the heads require special tools for driving and removing. These special tools are usually included in a kit that comes with the machine or installation on which the screws are used.

Fits

At one time each manufacturer made as many threads per inch on bolts, screws, and nuts as suited his own particular needs. For example, one made 12 threads per inch on 1/2" bolts while another might put on 13 or 15 threads per inch. Thus the bolts of one manufacturer would not fit the nuts made by another.

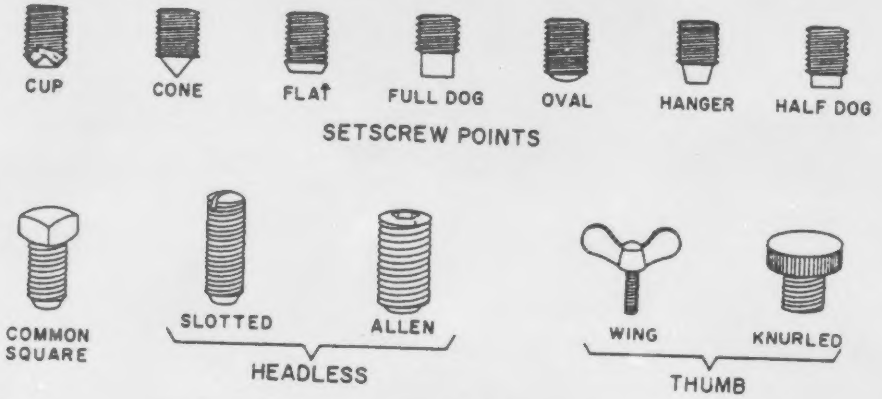


Figure 4-8.—Setscrews and thumb screws. 29.123F

The National Screw Thread Commission studied the problem and decided to standardize on a two-thread series, one called the NATIONAL COARSE THREAD SERIES (NC) and the other the NATIONAL FINE THREAD SERIES (NF). The SOCIETY OF AUTOMOTIVE ENGINEERS decided to standardize on some EXTRA FINE (EF) threads to be used in airplanes, automobiles, and other places where extra fine threads are needed. Table 4-2 shows the number of threads per inch for NC, NF, and EF thread sizes up to 1 inch in diameter. Four classes of fits were also established by the National Screw Thread Commission. They are: Class I, loose fit; Class II, free fit; Class III, medium fit; and Class IV, close fit.

The loose fit is for threaded parts that can be put together quickly and easily even when the threads are slightly bruised or dirty, and when a considerable amount of shake or looseness is not objectionable. The free fit is for threaded parts that are to be put together nearly or entirely with the fingers and a little shake or looseness is not objectionable. This includes most of the screw thread work. The medium fit is for the higher grade of threaded parts where the fit is somewhat closer. The close fit is for the finest threaded work where very little shake or looseness is desirable and where a screwdriver or wrench may be necessary to put the parts together. The manufacture of threaded parts belonging to this class requires the use of fine tools and gages. This fit should, therefore, be used only when requirements are exacting or where special conditions require screws having a fine, snug fit.

CAPSCREWS

Capscrews perform the same functions as machine screws, but come in larger sizes for heavier work. Sizes range up to 1 inch in diameter and 6 inches in length.

Capscrews are usually used without nuts. They are screwed into tapped holes, and are sometimes referred to as tap bolts. Threads may be either NF or NC.

Capscrews may have square, hex, flat, button, or fillister heads (fig. 4-7). Fillister heads are best for use on moving parts when such heads are sunk into counterbored holes. Hex heads are usually used where the metal parts do not move.

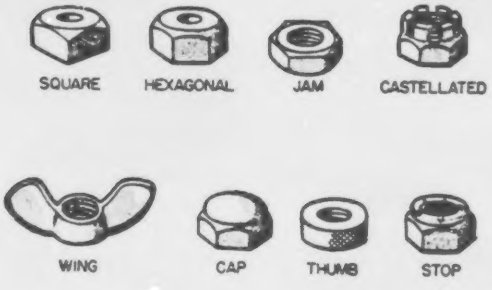
The strongest capscrews are made of alloy steel, and can withstand great stresses, strains, and shearing forces. Capscrews made of Monel metal are often specified on machinery that is exposed to salt water.

Some capscrews have small holes through their heads. A wire, called a SAFETY WIRE, is run through the holes of several capscrews to keep them from coming loose.

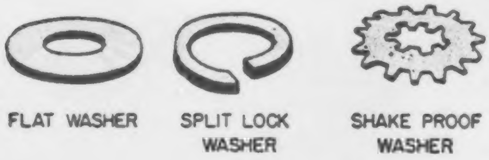
SETSCREWS

Setscrews are used to secure small pulleys, gears, and cams to shafts, and to provide positive adjustment of machine parts. They are classified by diameter, thread, head shape, and point shape. The point shape is important because it determines the holding qualities of the setscrew.

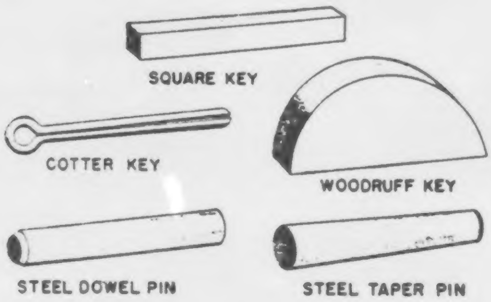
Setscrews hold best if they have either a CONE POINT or a DOG POINT, shown in figure


SQUARE
HEXAGONAL
JAM
CASTELLATED
WING
CAP
THUMB
STOP

44.63
Figure 4-9.—Common kinds of nuts.


FLAT WASHER
SPLIT LOCK WASHER
SHAKE PROOF WASHER

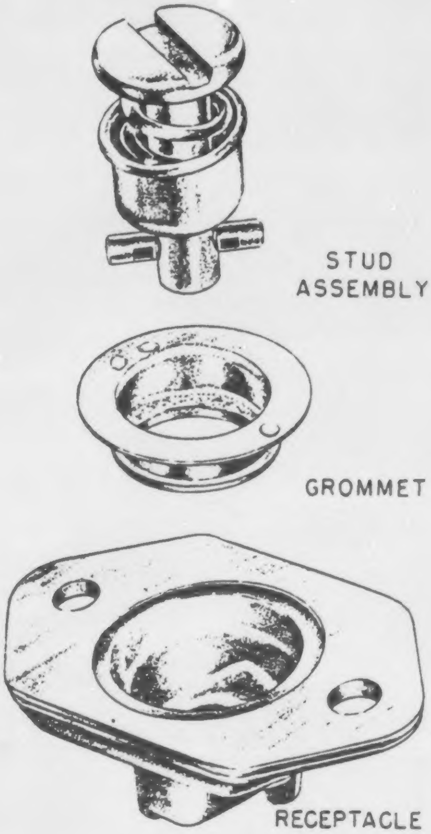
44.64
Figure 4-10.—Washers.


SQUARE KEY
COTTER KEY
WOODRUFF KEY
STEEL DOWEL PIN
STEEL TAPER PIN

44.65
Figure 4-11.—Keys and pins.

4-8. These points fit into matching recesses in the shaft against which they bear.

HEADLESS SETSCREWS—slotted, Allen or Bristol types—are used with moving parts because they do not stick up above the surface. They are threaded all the way from point to head. COMMON SETSCREWS, used on fixed parts, have square heads. They have threads all the way from the point to the shoulder of the head.


STUD ASSEMBLY
GROMMET
RECEPTACLE

44.218
Figure 4-12.—Camloc fastener.

THUMB SCREWS are used for setscrews, adjusting screws, and clamping screws. Because of their design they can be loosened or tightened without the use of tools.

NUTS

SQUARE and HEXAGONAL nuts are standard but they are supplemented by special nuts. (See fig. 4-9.) One of these is the JAM NUT, used above a standard hex nut to lock it in position. It is about half as thick as the standard hex nut, and has a washer face.

CASTELLATED nuts are slotted so that a safety wire or COTTER KEY may be pushed through the slots and into a matching hole in the bolt. This provides a positive method of

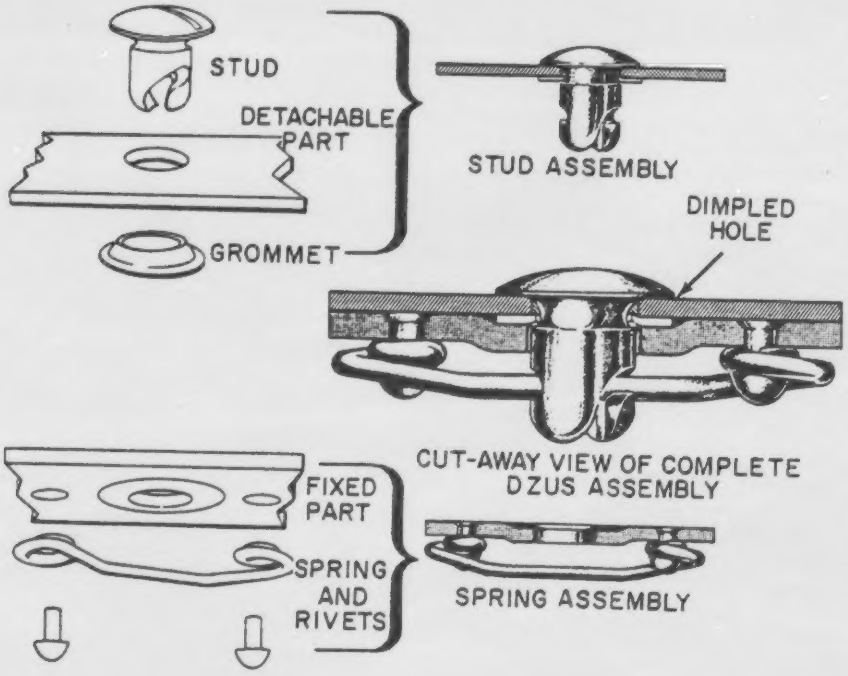


Figure 4-13.—Dzus fastener.

44.219

preventing the nut from working loose. For example, you will see these nuts used with the bolts that hold the two halves of an engine connecting rod together.

WING NUTS are used where the desired degree of tightness can be obtained by the fingers. CAP nuts, are used where appearance is an important consideration. They are usually made of chromium plated brass. THUMB NUTS are knurled, so they can be turned by hand for easy assembly and disassembly.

ELASTIC STOP NUTS are used where it is imperative that the nut does not come loose. These nuts have a fiber or composition washer built into them which is compressed automatically against the screw threads to provide holding tension. They are used extensively on radio, sound equipment, fire control equipment and on aircraft.

WASHERS

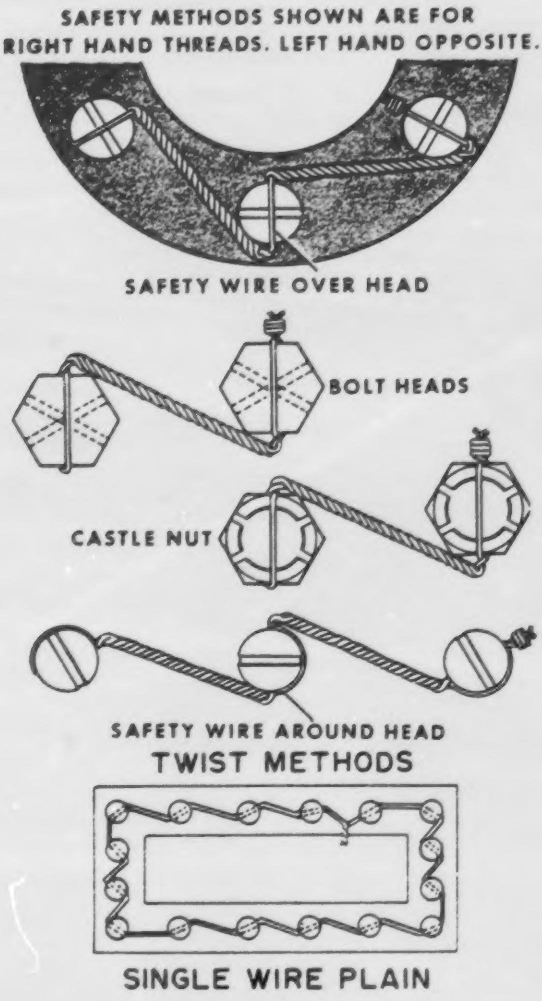
Figure 4-10 shows the types of washers used extensively throughout the Navy. FLAT WASHERS are used to back up bolt heads and nuts, and to provide larger bearing surfaces. They prevent damage to the surfaces of the metal parts.

SPLIT LOCK WASHERS are used under nuts to prevent loosening by vibration. The ends of these spring-hardened washers dig into both the nut and the work to prevent slippage.

SHAKEPROOF LOCK WASHERS have teeth or lugs that grip both the work and the nut. Several patented designs, shapes, and sizes are obtainable.

KEYS AND PINS

COTTER KEYS (fig. 4-11) are used to secure screws, nuts, bolts, and pins. They are also used as stops and holders on shafts and rods. SQUARE KEYS and WOODRUFF KEYS are used to prevent hand wheels, gears, cams and pulleys from turning on a shaft. These keys are strong enough to carry heavy loads if they are fitted and seated properly.



12.245(44B)A

Figure 4-14.—Safety wiring methods.

TAPER PINS are used to locate and position matching parts. They are also used to secure small pulleys and gears to shafts. They usually have a taper of 1/4-inch per foot. Holes for taper pins must be reamed with tapered reamers. If this is not done the taper pin will not fit properly.

DOWEL PINS are used to position and align the units or parts of an assembly. One end of a dowel pin is chamfered, and it is usually .001 to .002 inch greater in diameter than the size of the hole into which the pin will be driven.

TURNLOCK FASTENERS

Turnlock fasteners are used to secure inspection plates, doors, and other removable panels on items of support equipment and aircraft. These fasteners are also referred to by such terms as quick-opening, quick-acting, and stress panel fasteners. The most desirable feature of these fasteners is that they permit quick and easy removal of access panels and doors for inspection and servicing.

Turnlock fasteners are manufactured and supplied by a number of manufacturers under various trade names. Some of the more common trade names are the Camloc and Dzus (pronounced zoo's) types.

CAMLOC FASTENERS

Camloc fasteners are made in a variety of styles and designs. Regardless of the particular style or shape, the Camloc fastener consists of a stud assembly, receptacle, and a grommet (fig. 4-12).

The stud assembly consists of a stud, a cross pin, spring, and spring cup. The assembly is so designed that it can be quickly inserted into the grommet by compressing the spring. Once installed in the grommet the stud assembly cannot be removed unless the spring is again compressed.

The grommet is a flanged sheet-metal ring made to fit into a hole in the access door or panel. It is ribbed and can be pressed or dimpled into place.

The receptacle consists of a metal forging mounted in a stamped sheet metal. It is riveted to the access opening frame attached to the structure or equipment.

A quarter turn clockwise of the stud screw locks the cross pin into the grooved receptacle. Conversely, a counterclockwise rotation releases the connection between the stud assembly and the receptacle.

DZUS FASTENERS

The Dzus fastener (fig. 4-13) consists of a rotatable stud, which may have a slot for a screwdriver, or a winged fitting on it for hand operation. It also has a permanently mounted spring and a grommet. The stud and grommet are mounted in the door or other removable part, and the spring is riveted to the frame of the access on which the door fits.

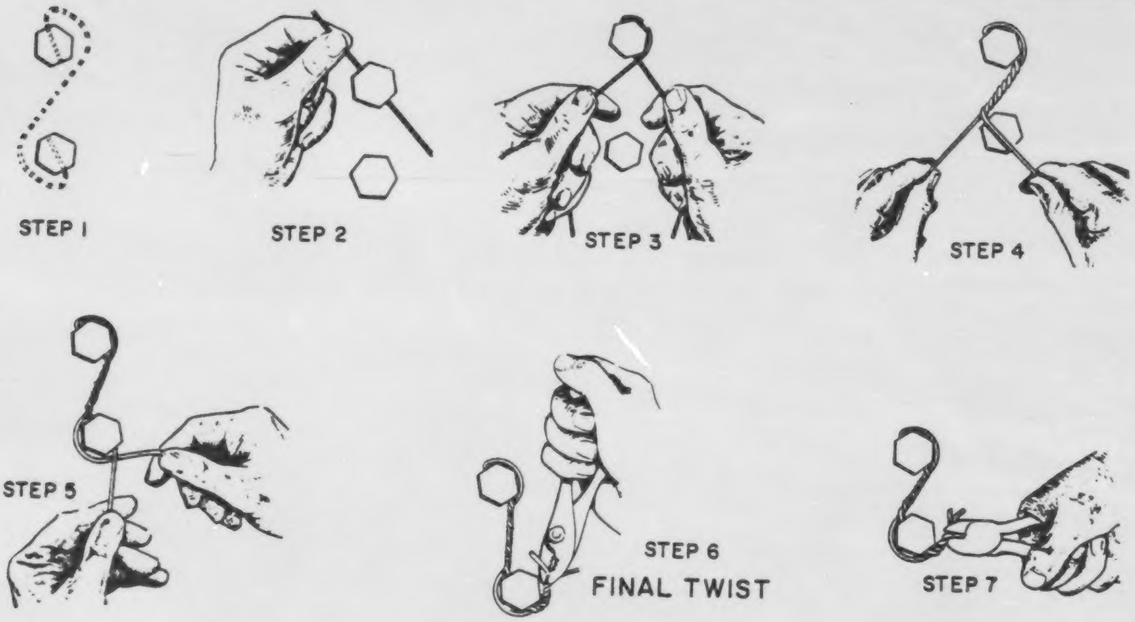

STEP 1
STEP 2
STEP 3
STEP 4
STEP 5
STEP 6
FINAL TWIST
STEP 7

Figure 4-15.—Standard twist safety wire installation procedure.

12.245(44B)B

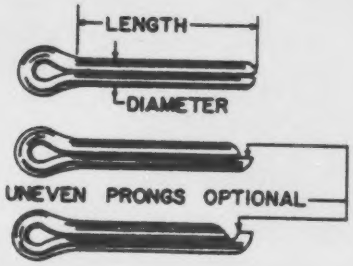

LENGTH
DIAMETER
UNEVEN PRONGS OPTIONAL

Figure 4-16.—Types of cotter pins.

44.65(44B)A

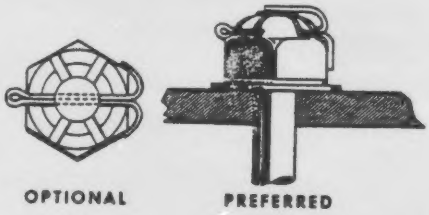

OPTIONAL
PREFERRED

Figure 4-17.—Cotter pin installations.

44.65(44B)B

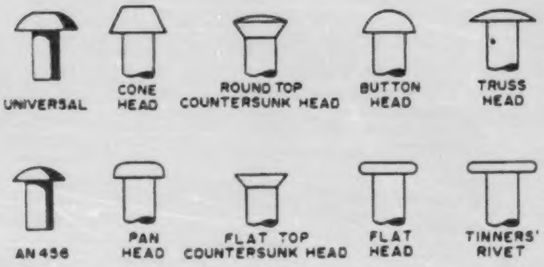
Cams on the stud engage with the spring to lock the fastener in the engaged position. The purpose of the grommet is to retain the stud in the access door. In some installations, the grommet is not used as a retainer; the stud is secured to the access door by a snapring, cup washer, or by dimpling of the metal around the stud.

The quick acting action of the Dzus fastener is achieved when a quarter turn rotation of the stud causes its engagement or disengagement with the spring.

SAFETYING METHODS

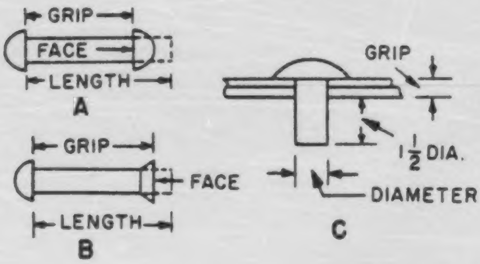
Safetying is a process of securing fasteners and other equipment so they do not work loose due to vibration. Loose bolts, screws and nuts or other parts can ruin delicate equipment or endanger life when they fall off equipment.

Various methods for safetying parts exist. The most widely used are safety wire and cotter



11.292A

Figure 4-18.—Some common types of rivets.



11.292B

Figure 4-19.—Showing what is meant by "grip" of a rivet.

Table 4-3.—Guide for Selecting Rivet Size for Sheet Metal Work

11.390

Gage of sheet metal	Rivet size (weight in pounds per 1000 rivets)
26	1
24	2
22	2 1/2
20	3
18	3 1/2
16	4

pins. Learn the proper techniques and USE them. YOUR LIFE may depend upon proper use of these techniques.

SAFETY WIRING

Safety wiring is the most positive and satisfactory method of safetying capscrews, studs, nuts, and bolt heads which cannot be safetied by any other practical means. It is a method of wiring together two or more units in such a manner that any tendency of one to loosen is countered by the tightening of the wire and the other unit. Components are safety wired by the single wire plain method or the twist method (fig. 4-14).

The single wire plain method may be used on small components in a closely spaced, closed geometrical pattern, and in places that are difficult to reach. When safety wiring closely spaced components, take advantage of safety wiring the whole series. The number of parts in the series safely wired together by this method depends upon the application; but the maximum number in the series is limited by a maximum 24 inch wire length.

The twist method is the most common method of safety wiring. The technique is shown in figure 4-15. A group of three should be the maximum in the series when safety wiring widely spaced components by this method.

The following general rules should be followed when using the safety wire method to secure components.

- The safety wire must be new upon each application.
- All safety wires must be tight after installation, but not under such tension that normal handling or vibration will break the wire.
- The wire must be applied so that all pull exerted by the wire tends to tighten the nut.
- Twists should be tight and even and the wire between the nuts as taut as possible without overtwisting. Wire twister pliers should be used if available; otherwise, wire between nuts should be twisted with the hands. The use of regular pliers for twisting will damage the wire. Regular pliers may be used only for the final end twist prior to cutting off the excess wire.
- When castellated nuts are to be secured, tighten the nut to the low side of the selected torque range, unless otherwise specified, and if necessary, continue tightening until a slot aligns with a hole.

COTTER PINS

Some cotter pins are made of low-carbon steel, while others consist of stainless steel

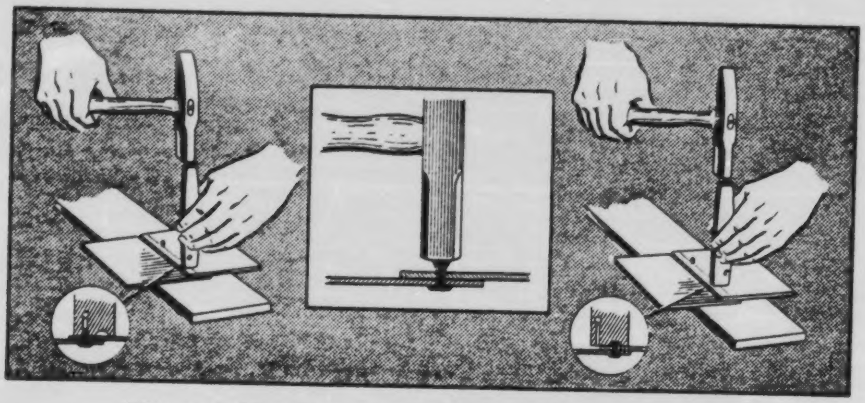
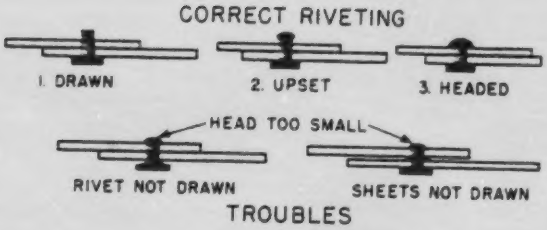


Figure 4-20.—Drawing, upsetting, and heading a rivet.

11.295



11.296

Figure 4-21.—Correct and incorrect riveting.

and thus are more resistant to corrosion. Regardless of shape or material, all cotter pins are used for the same general purpose—safetying.

Dimension perimeters of a cotter pin are shown in figure 4-16. Whenever uneven prong cotter pins are used, the length measurement is to the end of the shortest prong.

A cotter pin installation is shown in figure 4-17. The cotter pin should fit neatly into the hole with very little sideplay.

In the preferred installation method, the bent prong above the bolt end should not extend beyond the bolt diameter. Additionally, the bent prong should not rest against the surface of the washer. Cut the prongs down to size if necessary.

If the optional wraparound method is used, the prongs should not extend outwards, but should be bent over a reasonable radius to the sides of the nut. Sharpangled bends invite breakage. Usually the initial bending of the prongs of a cotter pin is accomplished with needle nose or diagonal pliers and the best tool for final bending of the prongs is a soft faced mallet.

RIVETS

Rivets are used extensively as a fastening device in aircraft. They are also used to join metal sheet when brazing, welding, or locking techniques will not provide a satisfactory joint.

RIVET TYPES

The major types of rivets used extensively include the standard type and pop rivets. Standard rivets must be driven using a bucking bar whereas the pop rivets have a self heading capability and may be installed where it is impossible to use a bucking bar.

Standard Rivets

Wherever possible, rivets should be made of the same material as the material they join. They are classified by lengths, diameters, and their head shape and size. Some of the standard head shapes are shown in figure 4-18.

Selection of the proper length of a rivet is important. Should too long a rivet be used, the formed head will be too large, or the rivet may bend or be forced between the sheets being riveted. Should too short a rivet be used, the

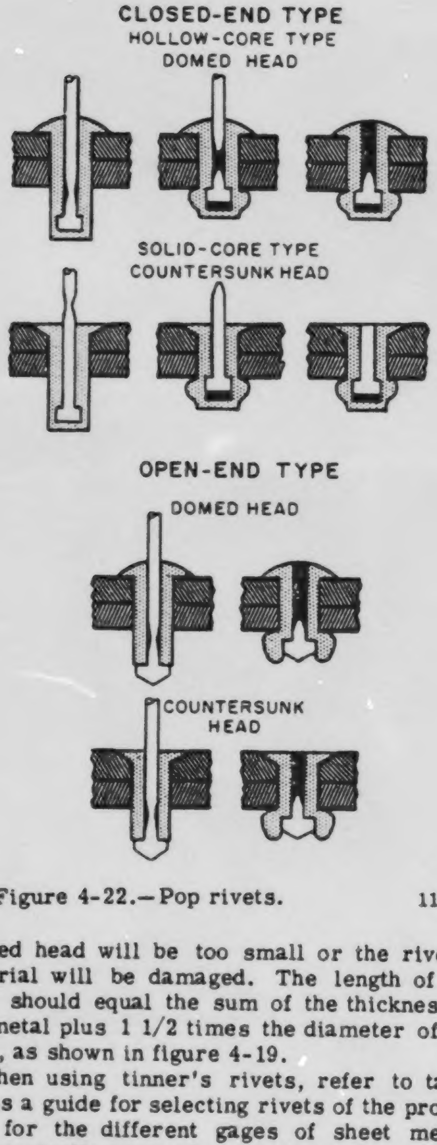
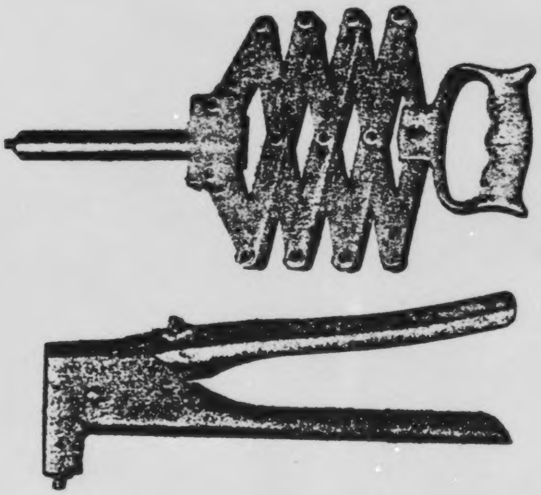
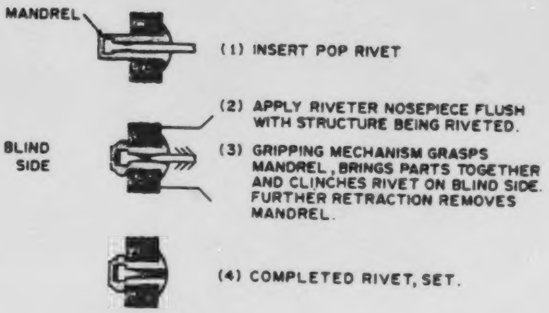

CLOSED-END TYPE
HOLLOW-CORE TYPE
DOMED HEAD
SOLID-CORE TYPE
COUNTERSUNK HEAD
OPEN-END TYPE
DOMED HEAD
COUNTERSUNK
HEAD

Figure 4-22.—Pop rivets. 11.292



11.374
Figure 4-23.—Pop rivet tools.


MANDREL
(1) INSERT POP RIVET
(2) APPLY RIVETER NOSEPIECE FLUSH WITH STRUCTURE BEING RIVETED.
BLIND SIDE
(3) GRIPPING MECHANISM GRASPS MANDREL, BRINGS PARTS TOGETHER AND CLINCHES RIVET ON BLIND SIDE. FURTHER RETRACTION REMOVES MANDREL.
(4) COMPLETED RIVET, SET.

11.292
Figure 4-24.—Setting pop rivets.

formed head will be too small or the riveted material will be damaged. The length of the rivet should equal the sum of the thickness of the metal plus 1 1/2 times the diameter of the rivet, as shown in figure 4-19.

When using tinner's rivets, refer to table 4-3 as a guide for selecting rivets of the proper size for the different gages of sheet metal.

The riveting procedure for the standard type of rivet involves three operations: drawing, upsetting, and heading as shown in figure 4-20. The sheets are drawn together by placing the deep hole of the rivet set over the rivet and striking the head of the set with a hammer. Upon removal of the set, the end of the rivet is struck lightly to upset the end of the rivet. Finally, the heading die (dished part) of the rivet set forms the head of the rivet when the hammer again strikes the head of the rivet set. The results of correct and incorrect riveting are shown in figure 4-21.

Pop Rivets

Pop rivets (fig. 4-22) have two advantages compared to standard rivets in that they can be set by one man and also be used for blind fastening. This means that they can be used where there is limited or no access to the reverse side of the work.

742

Operation is simple. Drill holes in the parts to be riveted together and align the holes. Insert the pop rivet (a hollow rivet assembled on a solid mandrel) and set it with a pop riveter (fig. 4-23) using the procedure shown in figure 4-24.

There are two basic designs for pop rivets: closed-end and open-end (fig. 4-22). The closed-end type rivet fills the need for blind rivets which seal as they are set. They are gas and liquid tight, when used properly, since a high degree of radial expansion provides excellent hole-filling characteristics and the mandrel head is within the core of the rivet body.

The open-end type is not liquid-tight because the mandrel head which remains in the rivet body is not enclosed within that body as is the closed-end type. This obviously leaves room for possible seepage of liquid or gas.

Pop type rivets discussed in this chapter have a variety of general purpose applications. Naval Aviation Maintenance activities utilize more sophisticated types of pop rivets. They are usually of higher strength alloys than common pop type rivets and include either friction or mechanical lock features which will ensure that they will not fail under vibration of the aircraft and its structure.

RIVET SELECTION

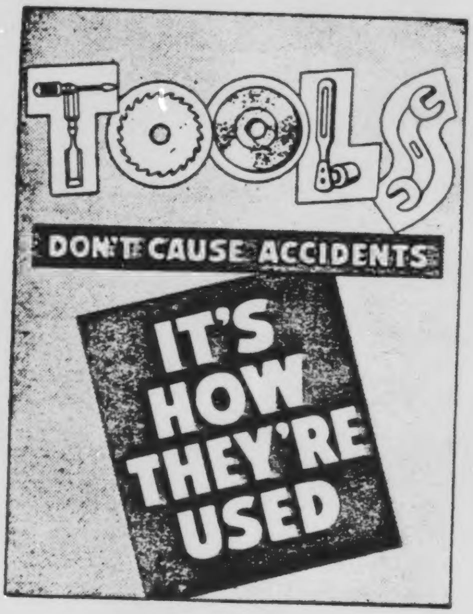
The following rules govern the selection and use of rivets in making a repair:

1. Replacements must not be made with rivets of lower strength material unless they are larger than those removed.

2. When rivet holes become enlarged, deformed, or otherwise damaged, use the next larger size as replacement.

3. Countersunk head rivets are to be replaced by rivets of the same type and degree of countersink.

4. Rivets selected for specific applications must always be of the type recommended in the repair manual for that particular equipment. Rivets are available in a variety of metals and alloys having specific shear strength and hardness characteristics. Selection of the wrong alloy/type rivet could produce hazardous results. Rivets common to aircraft and aerospace equipment application are identified by head or shank markings. In all cases, choose a rivet that is capable of meeting the load and holding requirements to which it will be subjected.



CHAPTER 5

GRINDING OPERATIONS

To keep hand tools in the best usable condition, cutting edges must be sharpened frequently and certain other tools trued or shaped for special purposes. Chisels, punches, drills, tinsnips, screwdrivers, and other hand tools are shaped or sharpened on an abrasive grinding wheel.

Grinding may be defined as the act of shaping or wearing down a surface or sharpening an edge by means of the cutting action of thousands of abrasive grains on the surface of the grinding wheel. Excessive grinding shortens the useful life of a tool.

A variety of grinding machines are in use in the Navy. Many of them are special machines used in tool and die making or machines used for other special purposes. The bench grinder, explained in chapter 2 of this text, is the type of grinder found in general use in the Navy. Nearly all mechanical shops in shore installations or aboard ship will have a bench grinder.

GRINDING SAFETY

The grinding wheel is a fragile cutting tool which operates at high speeds. Great emphasis must be given, therefore, to the safe operation of bench and pedestal grinders. Observance of safety precautions, posted on or near all grinders used in the Navy, is mandatory for the safety of the operator and the safety of personnel in the nearby vicinity.

What are the most common sources of injury during grinding operation? Hazards leading to eye injury caused by grit generated by the grinding process are the most common and the most serious. Abrasions caused by bodily contact with the wheel are quite painful and can be serious. Cuts and bruises caused by segments of an exploded wheel, or a tool "kicked" away from the wheel are other sources of injury. Cuts and abrasions can become infected if not protected from grit and dust from grinding.

Safety in using bench and pedestal grinders is primarily a matter of using common sense and concentrating on the job at hand. Each time you start to grind a tool, stop briefly to consider how observance of safety precautions and the use of safeguards protect you from injury. Consider the complications that could be caused by your loss of sight, or loss or mutilation of an arm or hand.

Some guidelines for safe grinding practices are:

1. Read posted safety precautions before starting to use a machine. In addition to refreshing your memory about safe grinding practices, this gets your mind on the job at hand.
2. Secure all loose clothing and remove rings or other jewelry.
3. Inspect the grinding wheel, wheel guards, the toolrest, and other safety devices to ensure they are in good condition and positioned properly. Set the toolrest so that it is within 1/8 inch of the wheel face and level with the center of the wheel.
4. Transparent shields, if installed, should be clean and properly adjusted. Transparent shields do not preclude the use of goggles as the dust and grit may get around a shield. Goggles, however, provide full eye protection.
5. Stand aside when starting the grinder motor until operating speed is reached. This prevents injury if the wheel explodes from a defect that has not been noticed.
6. Use light pressure when starting grinding; too much pressure on a cold wheel may cause failure.
7. Grind only on the face or outer circumference of a grinding wheel unless the wheel is specifically designed for side grinding.
8. Use a coolant to prevent overheating the work.
9. Wear goggles and respiratory filters to protect your eyes and lungs from injury by grit and dust generated by grinding operations.

GRINDING WHEELS

A grinding wheel is composed of two basic elements: (1) the abrasive grains, and (2) the bonding agent. The abrasive grains may be compared to many single point tools embedded in a toolholder of bonding agent. Each of these grains extracts a very small chip from the material as it makes contact on each revolution of the grinding wheel.

An ideal cutting tool is one that will sharpen itself when it becomes dull. This, in effect, is what happens to the abrasive grains. As the individual grains become dull, the pressure that is generated on them causes them to fracture and present new sharp cutting edges to the work. When the grains can fracture no more, the pressure becomes too great and they are released from the bond, allowing new sharp grains to be presented to the work.

SIZES AND SHAPES

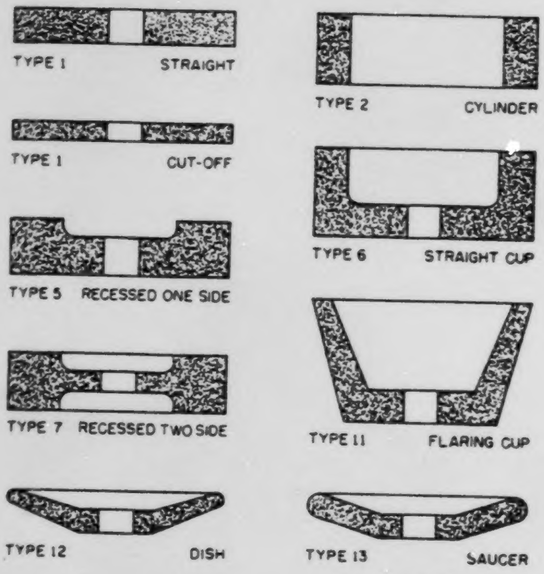
Grinding wheels come in various sizes and shapes. The size of a grinding wheel is given in terms of its diameter in inches, the diameter of the spindle hole, and the width of the face of the wheel. The shapes of all grinding wheels are too numerous to list in this manual, but figure 5-1 shows most of the more frequently used wheel shapes. The type numbers are standard and are used by all manufacturers. The shapes are shown in cross-sectional views. The specific job will dictate the shape of wheel to be used.

WHEEL MARKINGS AND COMPOSITION

Grinding wheel markings are comprised of six sections. Figure 5-2 illustrates the standard marking and possible variations. The following information breaks the marking down and explains each section. This information should be studied carefully as it will be invaluable in making the proper wheel selection for each grinding job you will attempt.

Kind of Abrasive

The first section on the wheel marking (reading from left to right) shows the abrasive type. There are two types of abrasives: natural and manufactured. Natural abrasives, such as emery, corundum, and diamond, are used only in honing stones and in special types of grinding wheels. The common manufactured abrasives are aluminum oxide and silicon carbide. They have superior qualities and are more economical than natural abrasives. Aluminum oxide (designated by the letter A) is used for grinding steel and steel alloys, and for heavy duty work such as cleaning up steel castings. Silicon carbide (designated by the letter C), which is harder but not as tough as aluminum oxide, is used mostly for grinding nonferrous metals and carbide tools. The abrasive in a grinding wheel comprises about 40 percent of the wheel.

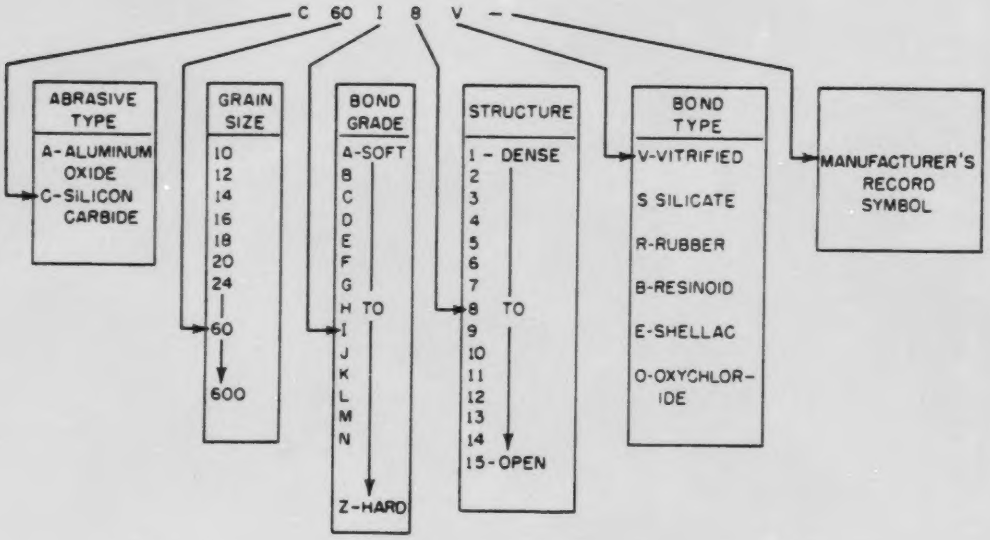


28.310

Figure 5-1.—Grinding wheel shapes.

Grain Size

The second section on the grinding wheel marking is the grain size. Grain sizes range from 10 to 600. The size is determined by the size of mesh of a sieve through which the grains can pass. Generally speaking, they are rated as follows: Coarse: 10, 12, 14, 16, 20, 24; Medium: 30, 36, 46, 54, 60; Fine: 70, 80, 90, 100, 120, 150, 180; and Very Fine: 220, 240, 280, 320, 400, 500, 600. Grain sizes finer than (240) are generally considered flour. Generally speaking, fine grain wheels are preferred for grinding hard materials, as they have more cutting edges and will cut faster than coarse grain wheels. Coarse grain wheels are generally preferred for rapid metal removal on softer materials.


C 60 I 8 V –
ABRASIVE TYPE
A- ALUMINUM OXIDE
C-SILICON CARBIDE
GRAIN SIZE
10
12
14
16
18
20
24
60
600
BOND GRADE
A-SOFT
B
C
D
E
F
G
H TO
I
J
K
L
M
N
Z-HARD
STRUCTURE
1 - DENSE
2
3
4
5
6
7
8 TO
9
10
11
12
13
14
15-OPEN
BOND TYPE
V-VITRIFIED
S SILICATE
R-RUBBER
B-RESINOID
E-SHELLAC
O-OXYCHLOR-IDE
MANUFACTURER'S RECORD SYMBOL

28.311

Figure 5-2.—Standard marking system for grinding wheels (except diamond).

Grade (Hardness)

Section three of the wheel marking is the grade or hardness of the wheel. As shown in figure 5-2, the grade is designated by a letter of the alphabet; grades run from A to Z or soft to hard.

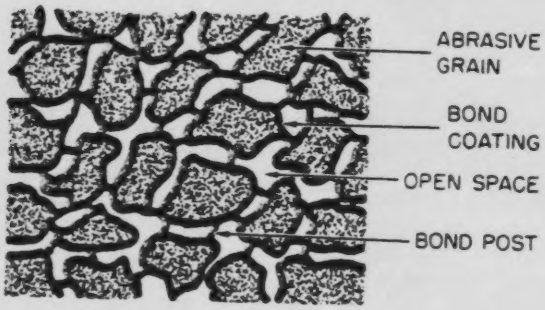
The grade of a grinding wheel is a measurement of the ability of the bond to retain the abrasive grains in the wheel. Grinding wheels are said to have a soft to hard grade. This does not mean that the bond or the abrasive is soft or hard; it means that the wheel has a large amount of bond (hard grade) or a small amount of bond (soft grade). Figure 5-3 illustrates a magnified portion of a soft grade and a hard grade wheel. You can see by the illustration that a part of the bond surrounds the abrasive grains and the remainder of the bond forms into posts that both hold the grains to the wheel and hold them apart from each other. The wheel having the larger amount of bonding material has thick bond posts and will offer great resistance to pressures generated in grinding. The wheel having the least amount of bond will offer less resistance to the grinding pressures. In other words, the wheel with a large amount of bond is said to be a hard grade and the wheel with a small amount of bond is said to be a soft grade.

Structure

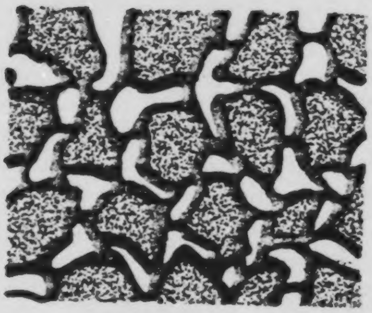
The fourth section of the grinding wheel marking is the structure. The structure is designated by numbers from 1 to 15, as illustrated in figure 5-2. The structure of a grinding wheel refers to the open space between the grains, as shown in figure 5-3. Grains that are very closely spaced are said to be dense; when grains are wider apart, they are said to be open. Generally speaking, the metal removal will be greater for open-grain wheels than for close-grain wheels. Also dense or close-grain wheels will normally produce a finer finish. The structure of a grinding wheel comprises about 20 percent of the grinding wheel.

Bond Type

The fifth section on the grinding wheel marking is the bond type. The bond comprises the remaining 40 percent of the grinding wheel and is one of the most important parts of the



WHEEL A



WHEEL B

28.312
Figure 5-3.—How bond affects the grade of the wheel. Wheel A, softer; Wheel B, harder.

wheel. The bond determines the strength of the wheel. The 6 basic types of bonds are considered in this chapter.

VITRIFIED bond, designated by the letter V, is not affected by oil, acid, or water. Vitrified-bonded wheels are strong and porous, and rapid temperature changes have little or no effect on them. Vitrified wheels should not be run in excess of 6500 surface feet per minute.

SILICATE bonded wheels are designated by the letter S. Silicate bonded wheels are used mainly for large, slow rpm machines where a cooler cutting action is desired. Silicate bonded wheels are said to be softer than vitrified wheels as they release the grains more readily than the vitrified bonded wheels. This wheel, like the vitrified bonded wheel, is not to be run in excess of 6500 surface feet per minute.

RUBBER bonded wheels, designated by the letter R, are strong and elastic. They are used for the manufacture of thin cutoff wheels and are used extensively for regulating wheels on centerless grinders. Rubber bonded wheels produce a high finish and can be run at speeds up to 16,000 surface feet per minute.

RESINOID bonded wheels are designated by the letter B and are shock resistant and strong. They are used for rough grinding and cutoff wheels. Resinoid wheels also can be run at speeds up to 16,000 surface feet per minute.

SHELLAC bonded wheels, designated by the letter E, give a high finish and have a cool cutting action when used as cutoff wheels. Shellac bonded wheels can be run up to 12,500 surface feet per minute.

OXYCHLORIDE bonded wheels are designated by the letter O. They are not to be run at speeds greater than 6,500 surface feet per minute.

Manufacturer's Record

The sixth section on the grinding wheel marking is the manufacturer's record. This may be a letter or number, or both. It is used by the manufacturer to designate bond modifications or wheel characteristics.

SELECTING AND USING THE WHEEL

The selection of grinding wheels for precision grinding can be discussed generally in terms of such factors as the physical properties of the material to be ground, the amount of stock to be removed (depth of cut), the wheel speed and work speed, and the finish required. Selection of a grinding wheel having the proper abrasive, grain, grade, and bond is determined by considering one or more of these factors.

An aluminum oxide abrasive is most suitable for grinding carbon and alloy steel, high speed steel, cast alloys and malleable iron. A silicon carbide abrasive is most suitable for grinding nonferrous metals, nonmetallic materials, and cemented carbides.

Generally, the softer and more ductile the material being ground, the coarser the grain selected should be. Also, if a large amount of material is to be removed, a coarse grain wheel is recommended (except on very hard materials). If a good finish is required, a fine grain wheel should be used.

For soft materials, small depth of cut, or high work speed, use a soft grade wheel. If the

Table 5-1.—Recommendations for Selecting Grinding Wheels

28.253.0

OPERATION	WHEEL DESIGNATION						MATERIAL
	Abrasive	Grain size	Grade	Structure	Bond	Mfg. Symbol	
Cylindrical grinding	A	60	K	8	V	- - - -	High speed steel
	A	60	L	5	V	- - - -	Hardened steel
	A	54	M	5	V	- - - -	Soft steel
	C	36	K	5	V	- - - -	Cast iron, brass, aluminum
	A	54	L	5	V	- - - -	General purpose
Surface grinding	A	46	H	8	V	- - - -	High speed steel
	A	60	F	12	V	- - - -	Hardened steel
	A	46	J	5	V	- - - -	Soft steel
	C	36	J	8	V	- - - -	Cast iron and bronze
	A	24	H	8	V	- - - -	General purpose
Tool and cutter grinding	A	46	K	8	V	- - - -	High speed steel or cast alloy milling cutter
	A	54	L	5	V	- - - -	Reamers
	A	60	K	8	V	- - - -	Taps

machine you are using is worn, a harder grade may be necessary to help offset the effects of wear of the machine. Using a coolant also permits the use of a harder grade of wheel.

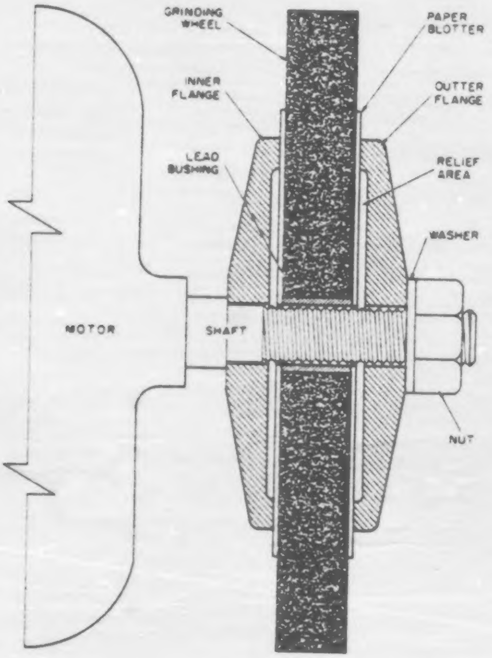
Table 5-1 lists recommended grinding wheels for various operations.

Before you perform these operations, you should be able, however, to install and dress the wheels properly, whenever required.

INSTALLING THE WHEEL

The wheel of a bench or pedestal grinder must be properly installed; otherwise accidents may occur and the wheel will not operate properly. Before a wheel is installed, it should be inspected for visible defects and "sounded" by tapping lightly with a piece of hard wood to determine whether it has invisible cracks. A good wheel gives out a clear ringing sound when tapped, but if the wheel is cracked a dull thud is heard. The following information on mounting the wheel should be more readily understood if the reader refers to figure 5-4.

Ensure that the shaft and flanges are clean and free of grit and old blotter material. Place the inner flange in place and follow it with a blotter. NOTE, the blotter thickness for paper must be no thicker than .025 inch and no thicker than .125 inch for leather or rubber. The blotter is used to ensure even pressure on the wheel, and to dampen the vibration between the wheel and shaft when the grinder is in operation. Next mount the wheel, and ensure that it fits on the shaft without play. A .002 to .005 inch clearance should be provided. This may be accomplished by scraping or reaming the lead bushing in the center of the wheel. NEVER FORCE THE WHEEL ON THE SHAFT. Forcing the wheel on the shaft may cause the wheel to crack when placed in operation, or cause the wheel to be slightly out of axial alignment.

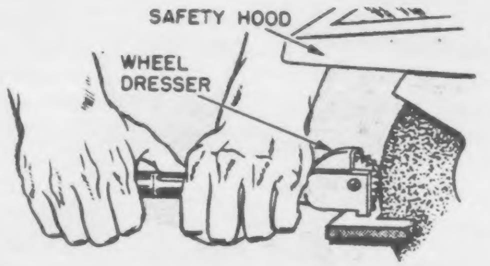


28.62(28D)
Figure 5-4.—Method of mounting a grinding wheel.

The next item is another blotter and then the outer flange. NOTE the flanges are recessed so they provide an even pressure on the wheel. The flanges should be at least one-third the diameter of the wheel. Next, install the washer and secure the nut. Tighten the securing nut sufficiently to hold the wheel firmly; tightening too much may damage the wheel.

TRUING AND DRESSING THE WHEEL

Grinding wheels, like other cutting tools, require frequent reconditioning of cutting surfaces to perform efficiently. Dressing is the term used to describe the process of cleaning the periphery of grinding wheels. This cleaning breaks away dull abrasive grains and smooths the surface so that there are no grooves. Truing is the term used to describe the removal of material from the cutting face of the wheel so that the resultant surface runs absolutely true to some other surface such as the grinding wheel shaft.



28.63
Figure 5-5.—Using a grinding wheel dresser.

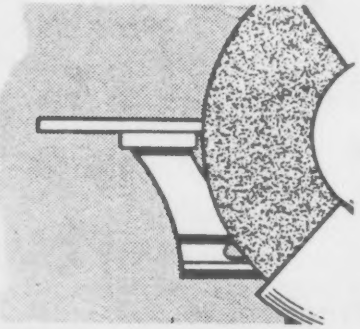
The wheel dresser shown in figure 5-5 is used for dressing grinding wheels on bench and pedestal grinders. To dress a wheel with this tool, start the grinder and let it come up to speed. Set the wheel dresser on the rest as shown in figure 5-2 and bring it in firm contact with the wheel. Move the wheel dresser back and forth across the face of the wheel until the surface is clean and approximately square with the sides of the wheel.

If grinding wheels get out of balance because of out-of-roundness, dressing the wheel will usually remedy the condition. A grinding wheel can get out of balance by being left sitting with part of the wheel immersed in the coolant; if this happens, the wheel should be removed and dried out by baking. If the wheel gets out of balance axially, it probably will not affect the efficiency of the wheel. This unbalance may be remedied simply by removing the wheel and cleaning the shaft spindle and spindle hole in the wheel and the flanges.

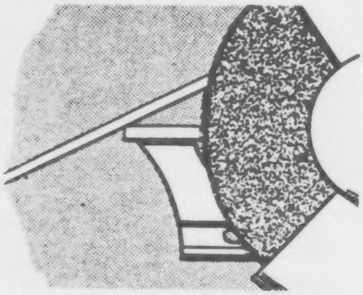
Each time that a wheel is dressed it is necessary that you check the clearance between the tool rest and the wheel. Reestablish the clearance at 1/16-inch as required. Adjustments must be made with the machine secured to preclude possible injury to the operator.

GRINDING METAL STOCK

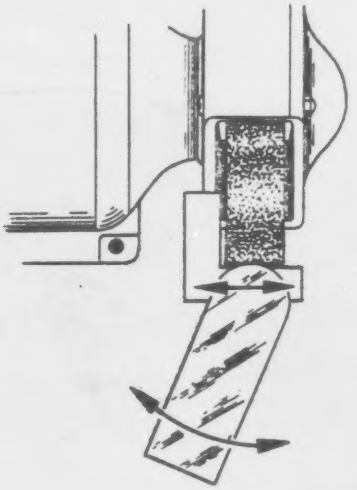
To grind a straight edge on metal stock (figure 5-6A) adjust the tool rest so that it just clears the wheel and is approximately at the center line of the wheel. Then, keeping the edge of the stock parallel with the center line of the grinder shaft, pass the stock across the face of the wheel. Grind across the entire width of the piece, using that pressure which will keep the



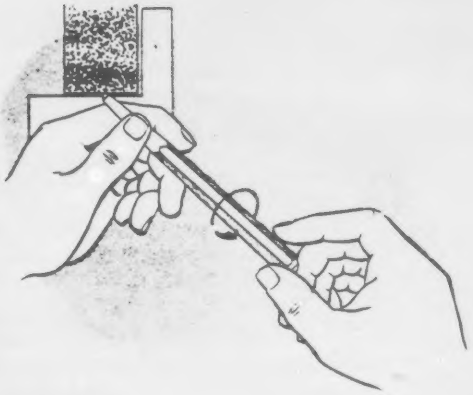
44.124
Figure 5-6A.—Grinding a straight edge on metal stock.



44.125
Figure 5-6B.—Grinding a bevel on metal stock.



44.126
Figure 5-7.—Grinding a rounded edge on metal stock.



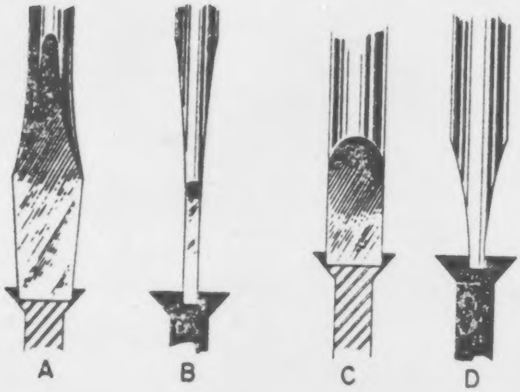
44.127
Figure 5-8.—Dressing a center punch with a bench grinder.

wheel cutting but will not appreciably decrease its speed. Grinding across the entire width of the piece and the wheel wears the wheel evenly and helps prevent overheating.

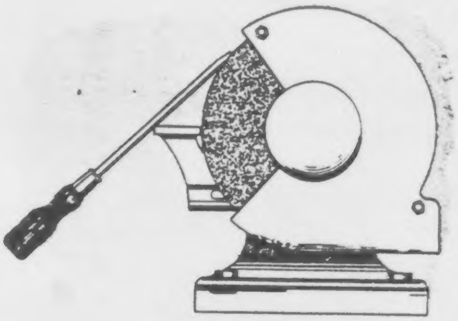
To grind a bevel on an edge, (figure 5-6B), hold the stock as shown so that it is resting both on the wheel and on the edge of the tool rest. The edge being ground is away from the tool rest and therefore is not liable to get caught between the tool rest and the wheel. Pass the stock across the face of the wheel just as you do when grinding a square edge.

To grind a rounded edge, set the tool rest at the center line of the wheel. With one hand, hold the end of the stock being ground so that you can move it from left to right, across the face of the wheel, as shown by the small double-headed arrow in figure 5-7, and also hold it down firmly on the tool rest. With the other hand swing the arc shown by the longer curved double-headed arrow at the opposite end of the stock. The motion indicated by the curved arrow will produce the rounded edge on the stock. The travel indicated by the short straight double-headed arrow will prevent the wearing of a groove in the wheel which would have to be removed by dressing.

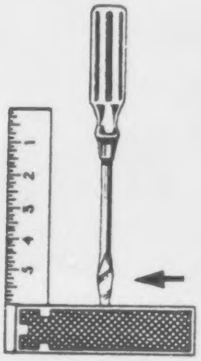
750



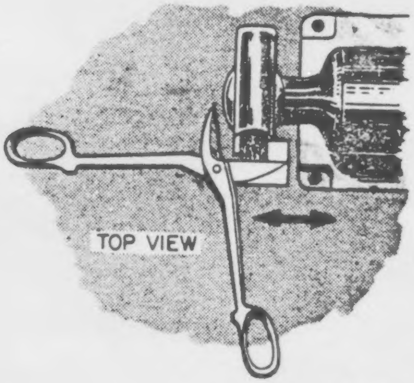
1.14.1A
Figure 5-9.—Shapes of screwdrivers when properly dressed.



1.14.1C
Figure 5-11.—Grinding a screwdriver tip with a bench grinder.



1.14.1B
Figure 5-10.—Checking the squareness of the end of a screwdriver.



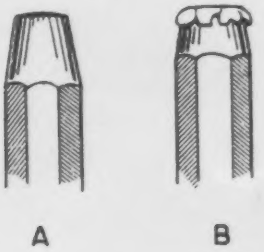
44.128
Figure 5-12.—Sharpening snips on a grinder.

CENTER PUNCH SHARPENING

To sharpen a center punch, cradle the end of the punch between the index finger and thumb of one hand, as shown in figure 5-8, resting that hand on the tool rest of the grinder. Move the punch into light contact with the rotating wheel of the grinder with the center line of the punch forming about a 45° angle with the face of the wheel. This will give the approximate 90° included angle required for a center punch. With the thumb and index finger of the other hand rotate the punch as shown by the directional arrow in figure 5-8. Keep the point cool by using only light pressure on the wheel and by frequently dipping the punch in a can of cooling water. Sharpen a prick-punch in the same way with the exception that, since the included angle should be 30° rather than 90°, the angle between the center line of this punch and the wheel should be about 15°.

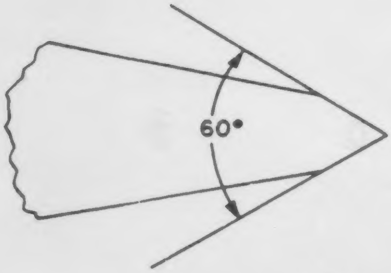
SCREWDRIVER TIP DRESSING

Figure 5-9, parts A and C are the front views of a properly dressed screwdriver; 5-9B and 5-9D are the side views.



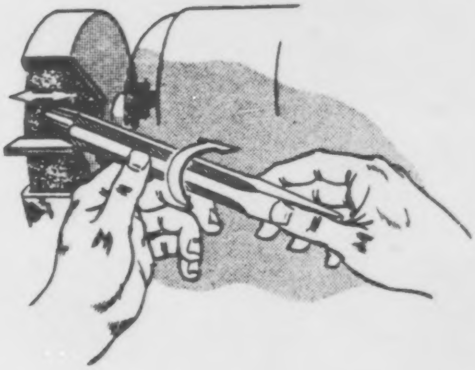
29.9K

Figure 5-13.—Good and bad shaped chisel heads.



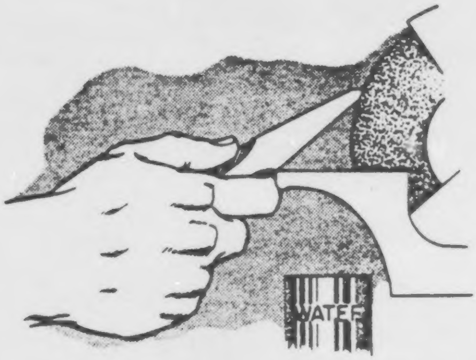
44.129

Figure 5-15.—Proper angle for general use cold chisel.



29.9L

Figure 5-14.—Grinding a chisel head with a bench grinder.



44.130

Figure 5-16.—Sharpening a chisel with a grinder.

To dress a common screwdriver, dress the sides so that the blade is symmetrical in shape. Then, square off the end. Check the squareness of the end by resting the tip on the handle of a trysquare and moving the shank of the screwdriver close to the blade of the square. If the blade and the shank appear to be parallel, the tip is square. See figure 5-10.

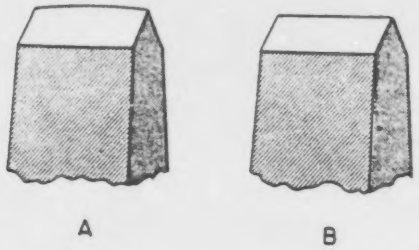
On the common screwdriver, grind the faces of the blade so that they are parallel or nearly parallel at the tip as shown at B and D in figure 5-9. The thickness of the blade at the tip should be such that the tip will just enter the slot of the screws you intend to turn. With such a tip thickness, and the sides parallel or nearly so, the screwdriver will have the least tendency to climb out of the screw slot when the screw is being turned home.

The screwdriver shown in figure 5-9D has been ground by resting it flat against the grinding wheel. A 6-inch wheel produces about the right grind on a screwdriver used for small screws. Hold the blade high on the circumference of the wheel and rest the shank on the tool rest. See figure 5-11.

When grinding a screwdriver, do not let the tip get too hot or the temper will be drawn. Overheating is discussed later in the section on sharpening metal-cutting chisels.

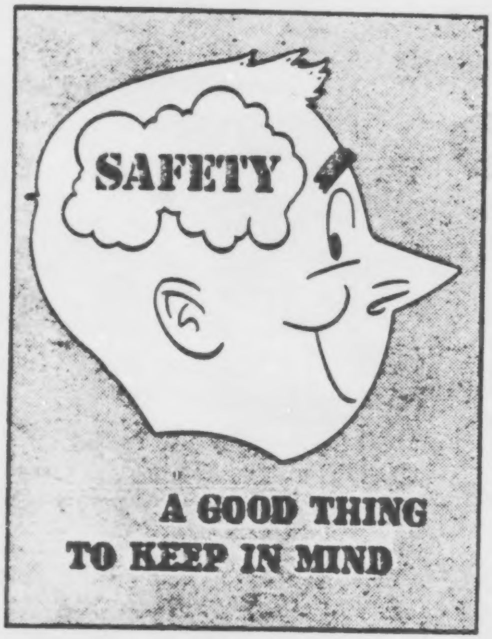
TIN SNIPS
SHARPENING

To sharpen tin ships on a grinder, open the snips as shown in figure 5-12, resting the blade on the tool rest. Hold level the handle of



44.131

Figure 5-17.—Two cutting edge shapes of cold chisels.


SAFETY
A GOOD THING TO KEEP IN MIND

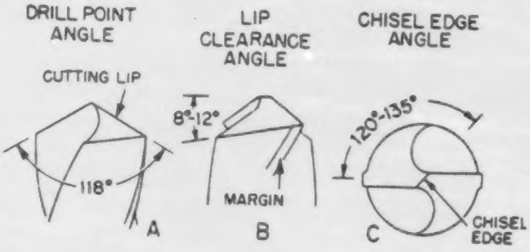
40.67

Figure 5-18.—Mental alertness is vital to safety.

CLEAN UP FOR SAFETY

40.67

Figure 5-19.—Eliminate potential hazards.


DRILL POINT ANGLE
LIP CLEARANCE ANGLE
CHISEL EDGE ANGLE
CUTTING LIP
118°
8°-12°
120°-135°
MARGIN
CHISEL EDGE
A
B
C

44.20S

Figure 5-20.—Specifications for grinding a regular point twist drill.

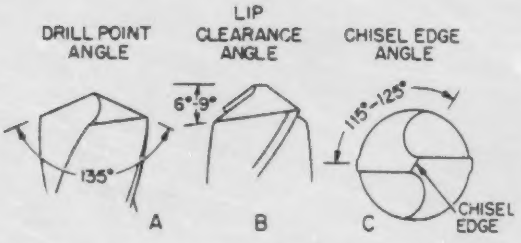
the blade being ground and then rotate the other blade at whatever angle is necessary to grind the cutting edge to an included angle of 80° to 85°. Holding the blade lightly against the rotating wheel, move it from left to right across the face of the wheel. Sharpen first one blade of the snips and then the other. While sharpening one blade, be careful to keep the other blade from coming into contact with the side of the wheel. Sharpening tin snips requires close and careful attention; improper techniques may result in wrecking the snips or even in serious personal injury.

CHISEL HEAD GRINDING

In figure 5-13A you will see a properly ground chisel head. Keep it that way by frequent grinding before it begins to mushroom as shown in figure 5-13B.

Never use a chisel whose head has been allowed to mushroom. You, or others, can be injured by chips or metal flying off the head when it is hammered.

Remove the ragged edges of such a head by grinding them off. One way to do this is to hold the head against the wheel as shown in figure 5-14.



44.20T

Figure 5-21.—Specifications for grinding a flat point twist drill.

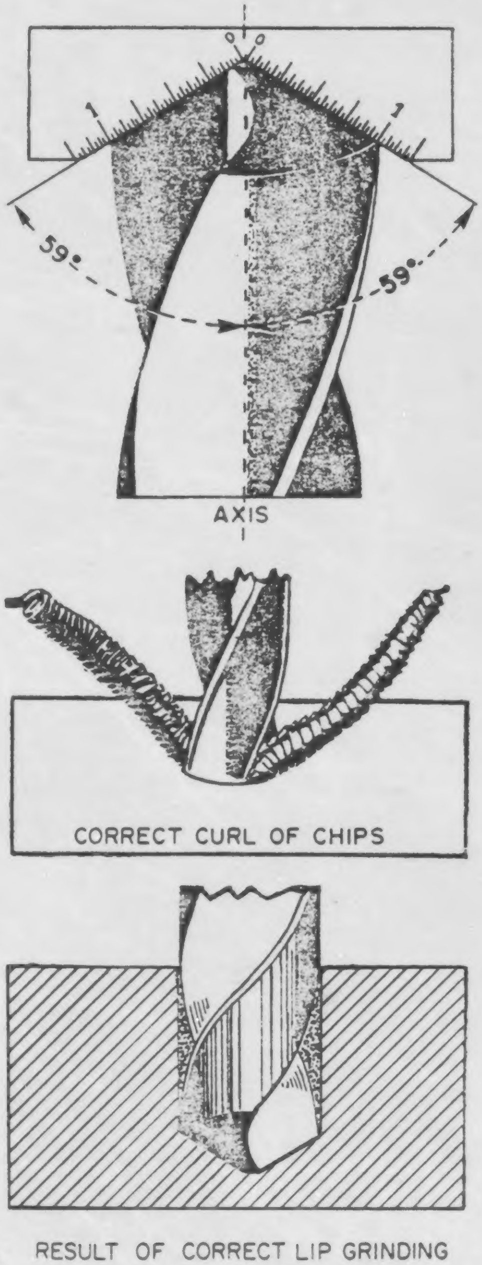
Turn the chisel with one hand as you apply pressure with the other. Grind across the entire face of the wheel to keep it flat.

SHARPENING METAL-CUTTING CHISELS

Metal-cutting chisels are sharpened by grinding. These chisels are designed to cut cold metal, so the general term "cold chisel" is often used. The angle of 60°, shown on the cold chisel in figure 5-15, is for a general-use cold chisel. Increase this angle somewhat for cutting harder metals and decrease it for those that are softer.

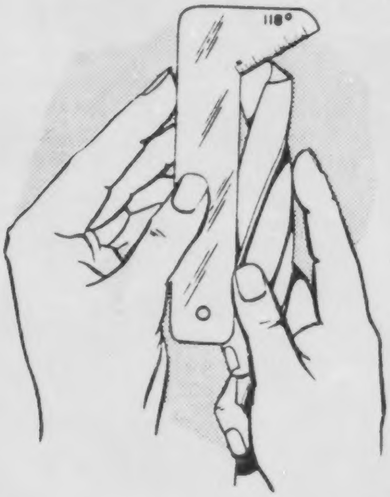
To sharpen a metal-cutting chisel, hold the chisel to the wheel, resting it on the tool rest. (See fig. 5-16.) Notice that the index finger, curved beneath the chisel, rides against the front edge of the tool rest. This affords good control of the chisel and will help you to grind a single, equal bevel on each side.

Let the chisel rest only lightly against the wheel when grinding. Less heat will be developed and, because the speed of the wheel is reduced only slightly, the air currents created by the wheel will have the maximum cooling effect. If the temperature of the cutting edge rises to the point where the metal begins to turn blue in color, the temper has been drawn, the cutting edge has been softened, and the edge will not stand up in use. The cutting edge will have to be rehardened, drawn to the proper temper (hardness), and the sharpening continued. As long as you can touch the cutting edge you are grinding with your bare hand and keep it there, you are in no danger of drawing the temper. Notice that it is the temperature of the cutting edge that is important. This means the very



44.20(44B)

Figure 5-22.—Grinding drill lips correctly.



44.20V
Figure 5-23.—Checking the drill point angle and cutting edge.

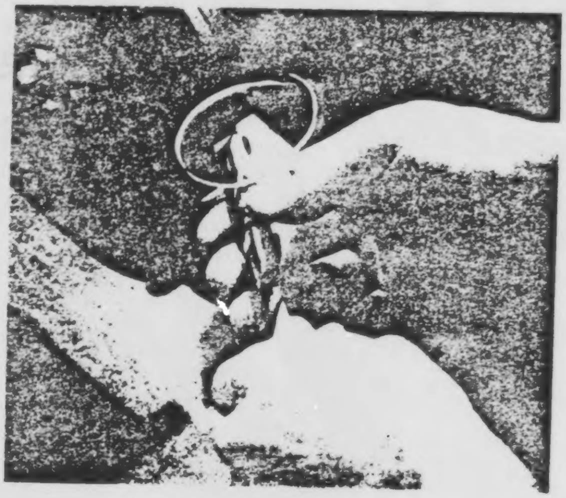
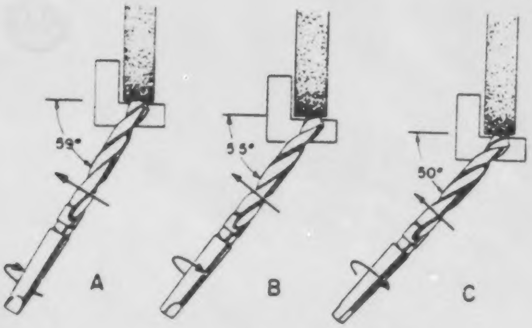
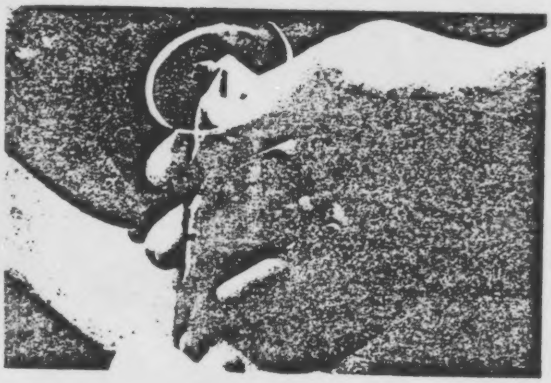


Figure 5-25.—Grinding a twist drill with a grinder (initial position). 44.20Y



44.20W
Figure 5-24.—Three steps for grinding a twist drill with a grinder.



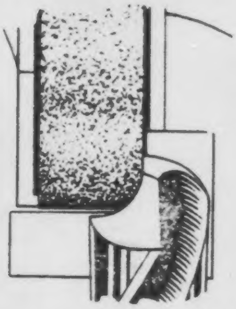
44.132
Figure 5-26.—Grinding a twist drill with a grinder (final position).

tip of the chisel where the bevel is being ground. The chisel at a point an inch or less from the cutting edge may be cool, while the cutting edge itself turns blue from overheating. Check this carefully while grinding.

Figure 5-17A shows a cold chisel ground with a slight curvature, and figure 5-17B shows a straight cutting edge. Both types of edges are used. The curved cutting edge is ground by swinging either end of the chisel slightly from left to right as the two faces of the cutting edge are being ground.

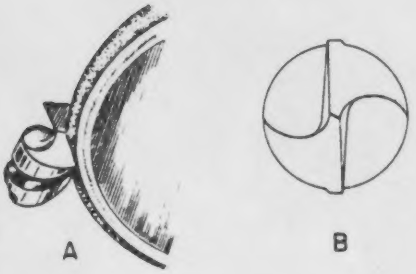
For shearing metal in a vise the chisel with the straight edge may be better. The chisel with the curvature will probably work better when you are cutting metal on a flat plate.

Be sure you are alert when you work (fig. 5-18). After you have completed your use of the tools, remove any possibility of danger from slipping or tripping (fig. 5-19).



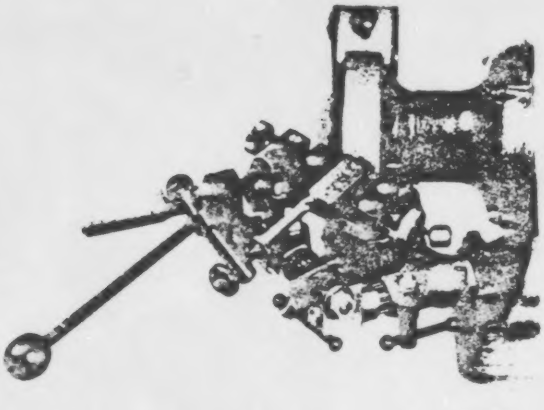
44.20AA.1

Figure 5-27.—Grinding a twist drill for brass.



44.20BB.1

Figure 5-28.—Thinning the web of a twist drill.



44.20Z

Figure 5-29.—Sharpening a twist drill with a tool grinder.

HAND SHARPENING TWIST DRILLS

The following requirements are of greatest importance in twist-drill grinding: (1) equal and correctly sized drill-point angles, (2) equal-length cutting lips, (3) correct clearance behind the cutting lips, and (4) correct chisel-edge angle. All four are equally important when grinding either a regular point (fig. 5-20), which is used for general purposes, or a flat point (fig. 5-21) which is used for drilling hard and tough materials.

Figure 5-22 shows the results of correct lip grinding and how equal drill point angles and two equal length cutting lips help achieve correct drill results.

Figure 5-23 shows a drill being checked during grinding. The drill-point gage is being held against the body of the drill and has been brought down to where the graduated edge of the gage is in contact with one cutting edge. In this way, both the drill-point angle and the length of the cutting edge (or lip) are checked at the same time. The process is repeated for the other side of the drill.

Lip clearance behind the cutting lip at the margin is determined by inspection. This means that you look at the drill point and approximate the lip-clearance angle (see figs. 5-20B and 5-21B), or compare it to the same angle that has been set up on a protractor. The lip-clearance angle is not necessarily a definite angle, but must be within certain limits. Notice that in figure 5-20B this angle ranges from 8° to 12° and that the range given in figure 5-21B is 6° to 9°. Whatever angle in the range is used, however, lip clearance should be the same for both cutting lips of the drill.

There must be lip clearance behind the entire length of the cutting lip which extends from the margin of the drill to the chisel edge. This means that there must be "relief" behind the cutting lip along its entire length.

When lip clearance is being "ground into" a drill, the lip-clearance angle and the chisel edge angle (shown at C in figs. 5-20 and 5-21) will be your guide to the amount of clearance you have ground into the drill behind the cutting lip along its entire length. The greater these angles are, the more clearance there will be behind their respective ends of the cutting lip. Too much lip clearance, which occurs when both the lip-clearance angle and the chisel-edge angle exceed their top limits, weakens the

756

cutting edge or lip by removing too much metal directly behind it. Too little or no lip clearance, prevents the cutting edge from producing a chip, or cutting, and the drill will not drill a hole.

To SHARPEN TWIST DRILLS, first get the grinder ready. If necessary, dress the face of the wheel so that it is clean, a true circle, and square with the sides. Before starting the grinder, readjust the tool rest to 1/16" or less from the face of the wheel. This is an important safety measure which will help keep work from wedging between the tool rest and the face of the wheel.

After starting the grinder and letting it come up to speed, you can begin grinding the drill point. Hold the twist drill as shown in figure 5-24A, which is a top view of the first step in grinding a drill. The axis of the drill, in the first step, should make an angle of about 59° (half of the drill-point angle) with the face of the wheel as shown in fig. 5-27A. The cutting lip should be horizontal. Figure 5-25 is an actual photograph, side view, of the same drill position which is shown in figure 5-24A.

The actual grinding of the drill point consists of three definite motions of the shank of the drill while the point is held lightly against the rotating wheel. These three motions are: (1) to the left, (2) clockwise rotation, (3) downward.

Figure 5-24 shows the motion to the left in three views as the angle between the face of the wheel and the drill decreases from about 59° to about 50°.

In figure 5-24 the clockwise rotation is indicated by the advance of the rotation arrows in A, B, and C. Rotation is also pictured by the change in position of the cutting lip as well as that of the tang.

Because figure 5-24 is a top view, the third (downward) motion is not noticeable. However, all three motions are apparent when an actual photograph of the final position of the drill in figure 5-26 is compared to the initial position in figure 5-25. All three motions taking place at the same time combine to produce the important requirements mentioned before (1) equal and correctly sized drill-point angles, (2) equal-length cutting lips, (3) correct clearance behind the cutting lips, and (4) correct chisel-edge angle. Checking by means of a drill-point gage, figure 5-23, and by inspection will show when these four requirements have been met.

SHARPENING A TWIST DRILL FOR DRILLING BRASS

To grind a drill for drilling brass hold the cutting lip against the right side of the wheel as shown in figure 5-27. Grinding the flute slightly flat, in line with the axis of the drill, greatly reduces the included angle of the cutting lip. This will give the drill a scraping action, necessary for brass, rather than the cutting action used for steel. This scraping action will prevent the tendency, that invariably occurs with drills not ground for brass, to stick in the hole being drilled. This sticking is troublesome especially when drilling through a pilot hole.

THINNING THE WEB OF A TWIST DRILL

Repeated sharpening, which shortens the drill, or the fact that the remaining length of a broken drill has been resharpened, results in an increase in the web thickness at the point. This may require web thinning. Correct web thinning, when it becomes necessary, is important for satisfactory drilling.

To thin the web of a drill, hold the drill lightly to the face of a round-faced wheel, as shown in figure 5-28A, and thin the web for a short distance behind the cutting lip and into the flutes. This is shown in figure 5-28B. Notice that the cutting lip is actually (but only slightly) ground back, reducing its included angle only a very little and not enough to affect the operation of the drill.

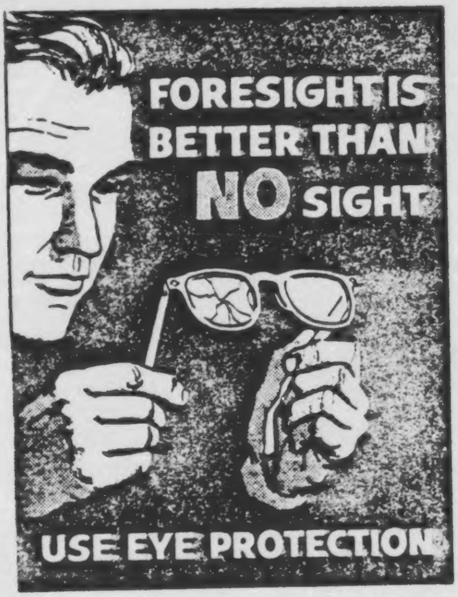
SHARPENING TWIST DRILL BY MACHINE

Sharpening a twist drill by hand is a skill that is mastered only after much practice and careful attention to the details. Therefore, whenever possible, use a tool grinder in which the drills can be properly positioned, clamped in place and set with precision for the various angles. This machine grinding (fig. 5-29) will enable you to sharpen the drills accurately. As a result, they will last longer and will produce more accurate holes.

Whether you are sharpening a drill by hand or by machine, it is very necessary that the temperature at the point be kept down. As the point gets hot, it approaches the temperature at which the temper of the steel will be drawn.

Keep the point cool enough to be held in your bare hand. Do this by making a few light passes over the grinding wheel. Take a few seconds to let the point cool and repeat alternate grinding and cooling.

Once you notice the appearance of a blue temper color at the point, it is too late. You have drawn the temper and the steel is now too soft to hold a cutting edge. Then the only thing you can do is to continue the sharpening process, first one lip and then the other, until you have finally ground away the soft tip of the drill. This means that you must grind away all that portion of the tip which is blue. As the blue color indicates softness throughout the entire point of the drill, and not only on the blue surface, resharpening must be continued until all of the blue-colored metal has been ground away. This operation must be done very slowly and carefully, keeping the point cool to prevent continual bluing of the metal.



CHAPTER 6

METAL CUTTING OPERATIONS

Many handtools and power tools have been designed for the specific purpose of cutting metals quickly and accurately. This chapter will describe some metal cutting operations that can be performed with chisels, drills, taps, dies, reamers, and pipe and tubing cutters.

METAL CUTTING WITH CHISELS

When struck with a heavy hammer, a cold chisel is capable of cutting metal. With chisel and hammer, you can cut wires, bars, rods and other shapes of metal and also cut off the heads of rivets and bolts.

CUTTING WIRE OR ROUND STOCK

Mark off a guideline on the stock and place the work on the top face of an anvil or other suitable working surface. Place the cutting edge of the chisel on the mark in a vertical position and lightly strike the chisel with a hammer. Check the chisel mark for accuracy. Continue to strike the chisel until the cut is made. The last few blows of the hammer should be made lightly to avoid damage to the anvil, supporting surface, or to the chisel.

Heavy stock is cut in the same manner except that the cut is made halfway through the stock; the work is then turned over and the cut finished from the opposite side.

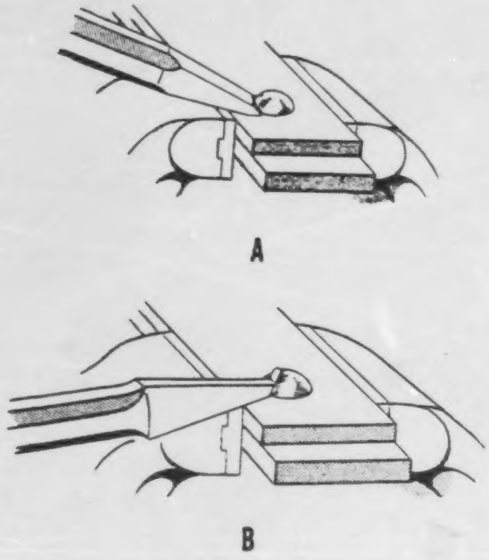
CUTTING OFF A RIVET OR BOLT HEAD

Hold the work in a heavy vise or secure it some other way so that the work will not move. (See fig. 6-1A.) Hold the cold chisel with one face of the bevel flat on the surface of the job. Strike the head of the chisel with the hammer as you loosely hold and guide the chisel.

To cut off a rivet head with a cape chisel, select a chisel of about the same size as the diameter of the rivet. Cut through the center of the rivet head, holding one face of the bevel flat on the surface of the job, and then sever the center of the head from the shank or body, as shown in figure 6-1B.

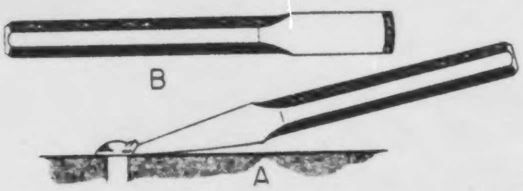
To cut off a rivet head with a side cutting chisel, place the chisel nearly flat on the surface of the work with its single bevel upwards. Drive the cutting edge under the edge of the rivet head just as you would if you were using a cold chisel. (See fig. 6-2A). Notice in figure 6-2B that the cutting edge of the chisel has a slight radius which will tend to prevent the corners from cutting undesirable grooves in the surface of the work.

To remove a rivet head (fig. 6-3) when there is not room enough to swing a hammer with sufficient force to cut the rivet, first drill a hole about the size of the body of the rivet in and almost to the bottom of the rivet head. Then cut off the head with a cold chisel.



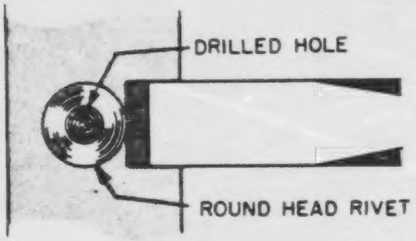
29.95

Figure 6-1.—Cutting off a rivet head with a chisel



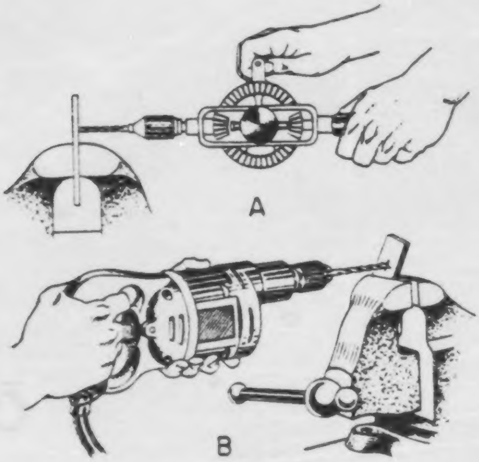
29.9T

Figure 6-2.—Cutting off a rivet head with a side cutting chisel.



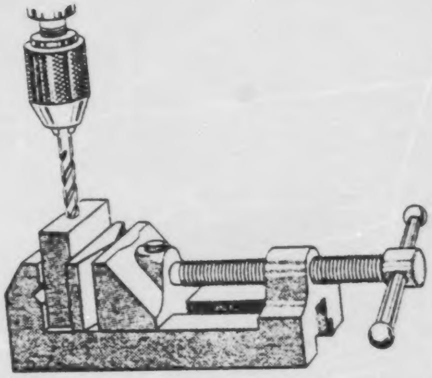
29.9U

Figure 6-3.—Removing a rivet head in a hard to reach position.



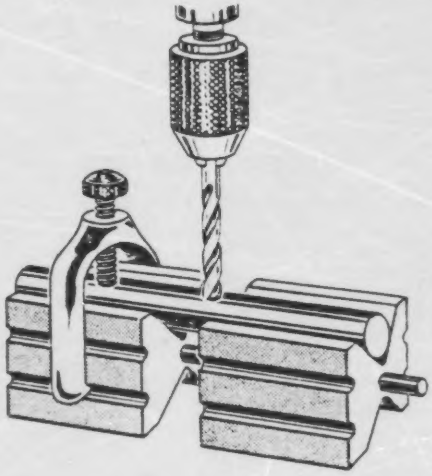
1.25

Figure 6-4.—Holding small pieces in a vise for drilling.



11.38

Figure 6-5.—Holding work with a drill press vise.



44.140

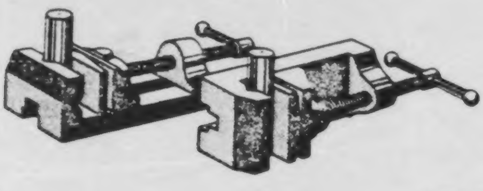
Figure 6-6.—Holding work in V-blocks.

METAL CUTTING WITH DRILLS

In drilling any metal, there are several general steps to be followed. First, mark the exact location of the hole. Second, secure the work properly. Then, use the correct cutting speed and appropriate cutting oil or other coolant, where applicable. Finally, apply pressure on the drill properly. It is assumed that you have selected the correct drill size.

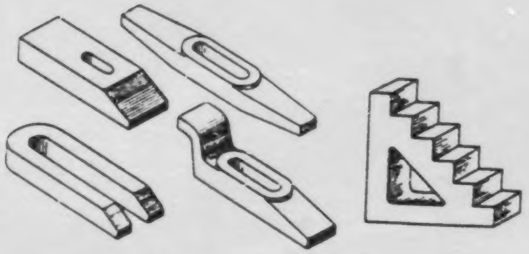
LOCATING THE HOLE

The exact location of the hole must be marked with a center punch. The punch mark



44.141

Figure 6-7.—Holding work to drill holes in the end of round stock.



11.15X

Figure 6-8.—Step block and clamps.

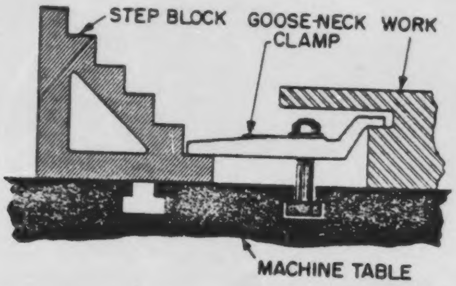
forms a seat for the drill point, thus ensuring accuracy. Without the punch mark, the drill may have a tendency to "walk off" before it begins to cut into the metal.

HOLDING THE WORK

Most work is held for drilling by some mechanical means such as a vise or clamps. It is MANDATORY that the work be WELL SECURED. If not, the work or stock may rotate at high speed or fly loose, and become a high speed projectile endangering all personnel within range. Various securing procedures are discussed in the following paragraphs.

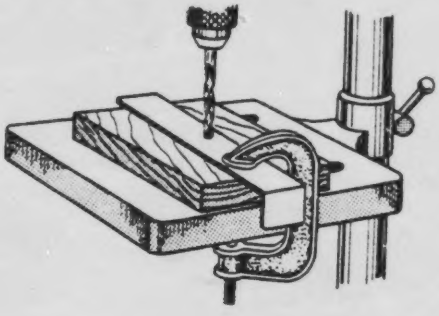
When drilling in small pieces with a hand held drill, it is best to hold the work in a vise so that the axis of the drill is horizontal (fig. 6-4). This position provides better control of the drilling operation and will tend to ensure a hole which will be square with the surface of the work.

When drilling in small pieces with a drill press, hold the work either in a drill press vise (fig. 6-5), or between V-blocks (fig. 6-6). CAUTION: BE SURE TO FASTEN THE DRILL PRESS VISE OR V-BLOCK TO THE DRILL PRESS TABLE.



28.231

Figure 6-9.—Holding work with step block and clamp for drilling.



44.140B

Figure 6-10.—Holding thin gage metal for drilling.

When using a drill press to drill holes in the end of round stock, place the stock in one of the V-grooves in the stationary jaw of the drill vise as shown in figure 6-7. These V-grooves will hold the work perpendicular to the table of the drill press. The drilled hole will then be parallel with the axis of the round stock.

Drilling holes in large pieces can be accomplished by holding the work with a step block and clamps (fig. 6-8). (A piece of metal of suitable size, with a hole drilled near one end makes a suitable substitute for a clamp.)

When holding work with step blocks and clamps, you may use a gooseneck clamp as shown in figure 6-9. Notice that the body of the clamp is approximately parallel with the surface of the drill press table and that the bolt is held close to the work rather than close to the step block. This setup provides the most

Table 6-1.—Drill Speeds in R.P.M

44.207

Diameter of Drill	Soft Metals 300 F.P.M.	Annealed Cast Iron 140 F.P.M.	Mild Steel 100 F.P.M.	Malleable Iron 90 F.P.M.	Hard Cast Iron 80 F.P.M.	Tool or Hard Steel 60 F.P.M.	Alloy Steel Cast Steel 40 F.P.M.
1/16 (No. 53 to 80)	18320	8554	6111	5500	4889	3667	2445
3/32 (No. 42 to 52)	12212	5702	4071	3666	3258	2442	1649
1/8 (No. 31 to 41)	9160	4278	3056	2750	2445	1833	1222
5/32 (No. 23 to 30)	7328	3420	2444	2198	1954	1465	977
3/16 (No. 13 to 22)	6106	2852	2037	1833	1630	1222	815
7/32 (No. 1 to 12)	5234	2444	1745	1575	1396	1047	698
1/4 (A to E)	4575	2139	1527	1375	1222	917	611
9/32 (G to K)	4071	1900	1356	1222	1084	814	542
5/16 (L, M, N)	3660	1711	1222	1100	978	733	489
11/32 (O to R)	3330	1554	1110	1000	888	666	444
3/8 (S, T, U)	3050	1426	1018	917	815	611	407
13/32 (V to Z)	2818	1316	939	846	752	563	376
7/16	2614	1222	873	786	698	524	349
15/32	2442	1140	814	732	652	488	326
1/2	2287	1070	764	688	611	458	306
9/16	2035	950	678	611	543	407	271
5/8	1830	856	611	550	489	367	244
11/16	1665	777	555	500	444	333	222
3/4	1525	713	509	458	407	306	204

Figures are for High-Speed Drills. The speed of Carbon Drills should be reduced one-half. Use drill speed nearest to figure given.

favorable mechanical advantage. Usually, two or more clamps are used on each setup.

If you are required to hold thin metal, place it on a block of wood to provide support directly beneath the intended hole. This support will also help minimize drill breakage when the feed pressure is applied. Secure the C-clamp as shown in figure 6-10 and drill through the metal and into the wood. Stop drilling when wood chips appear to avoid damage to the drill table.

SPEED INFORMATION

The correct cutting speed for metal drilling depends upon the type of metal and its properties plus the diameter and type of drill (high speed or carbon). See Table 6-1.

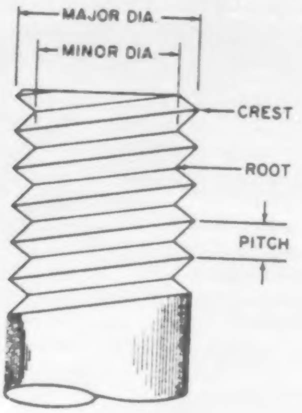
DRILLING HINTS

It is necessary to use a cutting oil to lubricate and cool the drill when drilling steel and wrought iron. Cast iron, aluminum, brass and other soft metals may be drilled dry, although at high drilling speeds it is advisable to use some medium to cool these metals. Compressed air, water, and lard oil are examples of such cooling media. Be sure to use goggles whenever you use compressed air.

Always apply pressure on a line which goes straight through the axis of the drill. (Side pressure will enlarge the hole and can break the drill.)

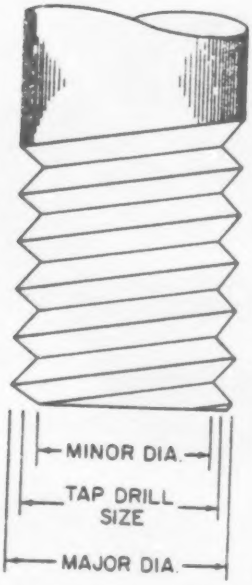
Keep the drill steady and apply enough pressure to keep it cutting. Too much pressure will overload the motor; too little pressure will merely cause the drill to "polish" instead of cut. This will quickly dull the cutting edges of the drill. You will know the pressure is correct when the drill bites continuously without overloading the drill motor.

When drilling large holes, do it in stages. A pilot hole is a good idea, since it serves as a guide for the larger drill and helps to increase accuracy.


MAJOR DIA
MINOR DIA
CREST
ROOT
PITCH

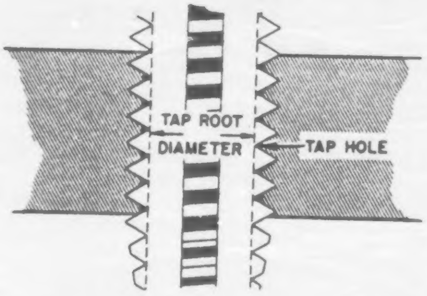
28.148(44B)A

Figure 6-11.—Thread terminology.


MINOR DIA
TAP DRILL SIZE
MAJOR DIA

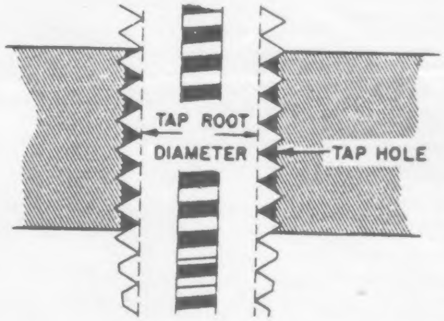
28.148(44B)B

Figure 6-12.—Tap drill size determination.


TAP ROOT DIAMETER
TAP HOLE

44.145

Figure 6-13.—Proper size drilled hole for tapping.


TAP ROOT DIAMETER
TAP HOLE

44.145A

Figure 6-14.—Oversize drilled hole for tapping.

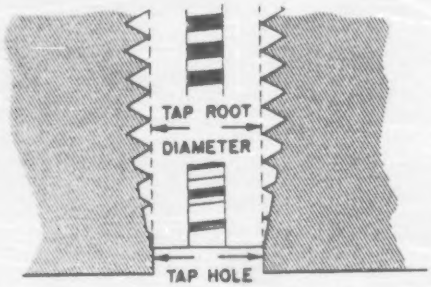
THREADS AND THREAD CUTTING

Threads are helical ridges cut into screws, nuts, bolts, or the walls of a hole, so that the action of turning the screw, nut, or bolt gives it endwise as well as rotary motion.

Many thread types exist. These types include bolt threads, machine screw threads and pipe threads. Before we proceed with descriptions of thread cutting procedures, we must become familiar with the terminology to be used.

THREAD TERMINOLOGY

Refer to figure 6-11 and note that the outside diameter of a thread is known as the MAJOR DIAMETER. The diameter across the roots of the thread is called the MINOR DIAMETER. The PITCH is defined as the distance from any point on the thread of a screw to the corresponding point on an adjacent thread. It is usually measured from crest to crest and is expressed by a specific quantity of threads per inch.



44.145B

Figure 6-15.—Undersize drilled hole for tapping.

TAP DRILL DETERMINATION

If a threaded hole is to be made in a piece of metal, a hole of suitable size must first be drilled. The hole must be somewhat smaller than the size of the bolt to be screwed into it.

How do you determine how much smaller to drill this hole? Figure 6-12 shows the system used for figuring this. The resultant thread is known as a "75% thread" because the diameter of the hole is 75% of the difference between the major and minor diameters, subtracted from the major diameter.

When the tap hole is the right size, it is a little larger than the root diameter of the tap as shown in figure 6-13. The tap will cut a thread in the work which is only 75 percent as deep as the thread on the tap. The other 25 percent of the depth of thread on the tap provides clearance between the tap hole and the root diameter of the tap. (See fig. 6-14.) This makes tapping easier.

If the tap drill selected is oversize, the tap hole will be oversize, and the tap can cut only shallow threads in the work. (See fig. 6-14.) With less than a full 75 percent depth of thread, stud or capscrew threads usually strip.

If the tap drill selected is undersize, the tap hole will be undersize, being perhaps equal to the root diameter of the tap as shown in figure 6-15. Then there will be no clearance, and the tap will turn hard, tear the threads, and probably break.

The best method to determine the exact size of tap drill to use is to refer to Table 6-2. A chart similar to this generally is included with a set of taps and dies. Let's see how this table is used.

The working drawing shown in figure 6-16 specifies a 1/2 in. 13 National Coarse (NC) thread to be tapped in a through hole in one part (1/2 in. deep hole in 1/2 in. stock). The same thread is to be tapped in a blind hole in another part (3/4 in. deep hole in 1 in. stock). The 1/2 in. round stock is to be threaded with this same thread to fit the tapped holes.

Refer to Table 6-2 and run down the first two columns until you locate 1/2—13 N.C. Follow this line to the right until you come to the tap drill size, 27/64 in. which will produce approximately a 75 percent full thread. Use the 27/64 in. drill to drill a through hole in the 1/2 in. block and a hole 3/4 in. deep in the 1-in. block as required by the working drawing.

CUTTING MACHINE THREADS WITH TAPS

A 50-50 mixture of white lead and lard oil, applied with a small brush, is highly recommended as a lubricant when tapping in steel. When using this lubricant, tighten the tap in the tap wrench and apply the lubricant to the tap. Start the tap carefully with its axis on the center line of the hole. The tap must be square with the surface of the work, as shown in figure 6-17.

To continue tapping, turn the tap forward two quarter turns, back it up a quarter turn to break the chips, and then turn forward again to take up the slack. Continue this sequence until the required threads are cut. After you cut for the first 2 or 3 full turns, you no longer have to exert downward pressure on the wrench. You can tell by the feel that the tap is cutting as you turn it. Don't permit chips to clog the flutes or they will prevent the tap from turning. When the tap won't turn and you notice a springy feeling, stop trying immediately. Back the tap up a quarter turn to break the chips, clean them out of the flutes with a wire as shown in figure 6-18, add some more lubricant, and continue tapping. When the tap has cut threads through the hole, the tap will turn with no resistance.

To tap a blind hole, start with the taper tap. For a blind hole you will need all three types—the taper, plug, and bottoming taps. Be sure they are the size and thread series you need, and that the tap hole is the size called for by the working drawing and Table 6-2.

Begin with the taper tap. Handle it as described and shown before. Figure 6-19A shows the taper tap just starting to cut. In figure

Table 6-2.—American National Form Threads

(Thread and Tap Drill Sizes)

44.205

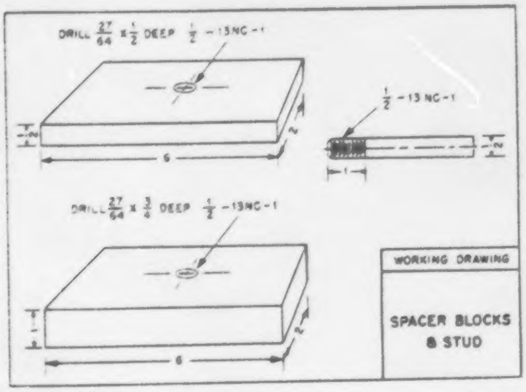
Nominal size	Thr'd series	Major diameter, inches	Root diameter, inches	Tap drill to produce approx. 75% full thread	Decimal equivalent of tap drill
0-80	N. F.	.0600	.0438	3/64	.0469
1-64	N. C.	.0730	.0527	53	.0595
72	N. F.	.0730	.0550	53	.0595
2-56	N. C.	.0860	.0628	50	.0700
64	N. F.	.0860	.0657	50	.0700
3-48	N. C.	.0990	.0719	47	.0785
56	N. F.	.0990	.0758	45	.0820
4-40	N. C.	.1120	.0795	43	.0890
48	N. F.	.1120	.0849	42	.0935
5-40	N. C.	.1250	.0925	38	.1015
44	N. F.	.1250	.0955	37	.1040
6-32	N. C.	.1380	.0974	36	.1065
40	N. F.	.1380	.1055	33	.1130
8-32	N. C.	.1640	.1234	29	.1360
36	N. F.	.1640	.1279	29	.1360
10-24	N. C.	.1900	.1359	25	.1495
32	N. F.	.1900	.1494	21	.1590
12-24	N. C.	.2160	.1619	16	.1770
28	N. F.	.2160	.1696	14	.1820
1/4-20	N. C.	.2500	.1850	7	.2010
28	N. F.	.2500	.2036	3	.2130
5/16-18	N. C.	.3125	.2403	F	.2570
24	N. F.	.3125	.2584	I	.2720
3/8-16	N. C.	.3750	.2938	5/16	.3125
24	N. F.	.3750	.3209	Q	.3320
7/16-14	N. C.	.4375	.3447	U	.3680
20	N. F.	.4375	.3726	25/64	.3906
1/2-13	N. C.	.5000	.4001	27/64	.4219
20	N. F.	.5000	.4351	29/64	.4531
9/16-12	N. C.	.5625	.4542	31/64	.4844
18	N. F.	.5625	.4903	33/64	.5156
5/8-11	N. C.	.6250	.5069	17/32	.5312
18	N. F.	.6250	.5528	37/64	.5781
3/4-10	N. C.	.7500	.6201	21/32	.6562
16	N. F.	.7500	.6688	11/16	.6875
7/8-9	N. C.	.8750	.7307	49/64	.7656
14	N. F.	.8750	.7822	13/16	.8125
1-8	N. C.	1.0000	8376	7/8	.8750
14	N. F.	1.0000	9072	15/16	.9375

6-19B it has cut a little farther. In figure 6-19C it has bottomed in the hole after having cut several full threads near the top of the hole. This completes the work to be done with the taper tap.

In figure 6-20A the plug tap has entered the few full threads cut by the taper tap. At figure 6-20B it has continued these threads a little farther down into the hole. At figure 6-20C it has bottomed in the hole. This is all the work that you can do with the plug tap. It has cut full threads about halfway down the tap hole before bottoming.

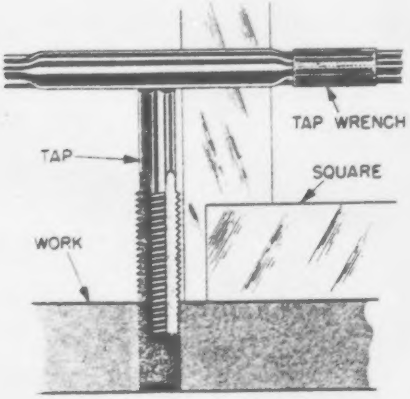
In figure 6-21 the bottoming tap has been substituted for the plug tap. In figure 6-21A it has been run down the full threads cut by the plug tap and is ready to cut more full threads. In figure 6-21B it has cut a few more threads, and in figure 6-21C it has bottomed in the hole. The blind hole has now been completely tapped.

Because these threads are being tapped in a blind hole, chip removal must be done differently. To remove chips, back the tap completely out of the hole very frequently, invert the stock, if possible, and jar out the chips or


DRILL $\frac{27}{64}$ x $\frac{1}{2}$ DEEP $\frac{1}{2}$ -13NC-1
$\frac{1}{2}$ -13 NC-1
6
2
1
DRILL $\frac{27}{64}$ x $\frac{3}{4}$ DEEP $\frac{1}{2}$ -13NC-1
WORKING DRAWING
SPACER BLOCKS & STUD

44.144

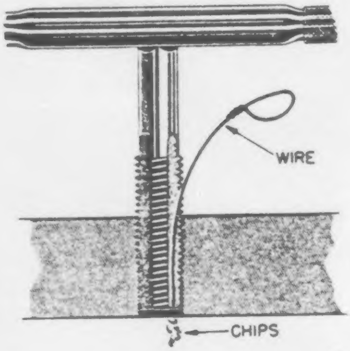
Figure 6-16.—A working drawing for tapping and cutting threads.


TAP WRENCH
TAP
SQUARE
WORK

44.146

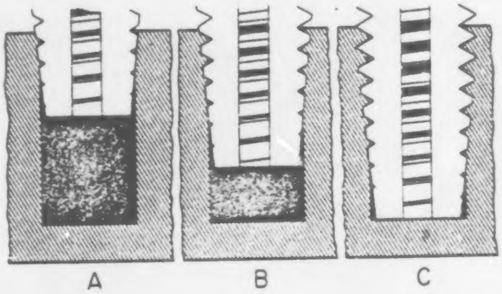
Figure 6-17.—Using a square to ascertain a tap is square with the work.

work them out of the hole with a wire while the stock is in the inverted position. If the work cannot be inverted, blow out the chips with air. Whenever you use air, BE SURE TO USE SAFETY GOGGLES. Chip removal in tapping blind holes is much more difficult to do and is very important because chips will fall ahead of the tap through the flutes and accumulate in the bottom of the blind hole. Until these chips are removed, none of the three taps can complete its work. In tapping blind holes alternate with tapping and chip removal until each of the three taps bottom in the blind hole.



44.146A

Figure 6-18.—Using a wire to clear chips from flute of a tap.



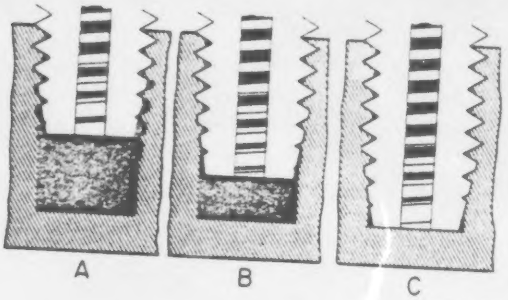
44.146B

Figure 6-19.—Tapping a blind hole with a taper tap.

When you have finished using the three taps, brush the chips out of their teeth, oil them well with lubricating oil, wipe off the surplus oil, and replace them in the threading set.

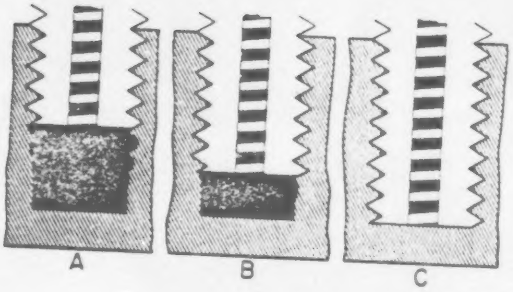
CUTTING MACHINE THREADS WITH DIES

To cut threads on a piece of round stock, first grind a chamfer on the end of the rod as shown in the working drawing in figure 6-16. Then hold the rod vertically in the vise to cut the threads. The working drawing in figure 6-16 calls for a 1/2-13N.C.-1 thread. The 1/2 signifies diameter and the 13 the number of threads per inch. The figure 1 after the N.C.



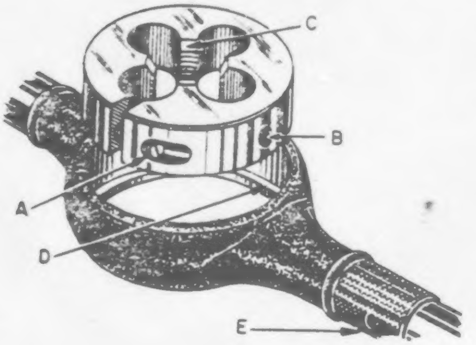
44.146C

Figure 6-20.—Tapping a blind hole with a plug tap.



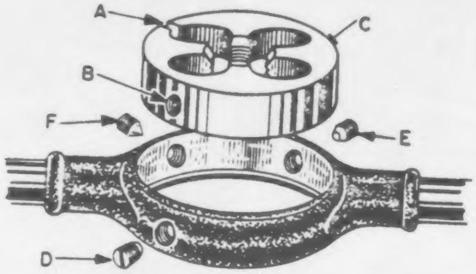
44.146D

Figure 6-21.—Finish tapping a blind hole with a bottoming tap.



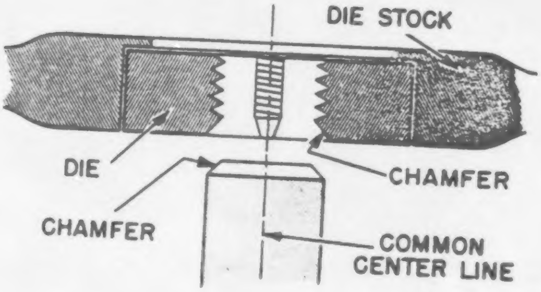
11.5.4A

Figure 6-22.—Assembling an adjustable round split die to diestock.



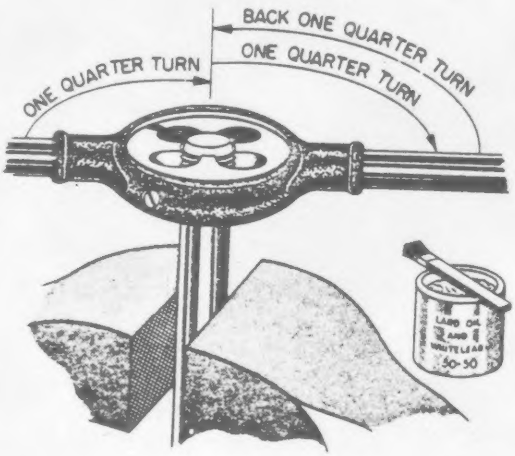
11.5.4B

Figure 6-23.—Assembling a plain round split die to diestock.


DIE STOCK
DIE
CHAMFER
CHAMFER
COMMON CENTER LINE

44.149

Figure 6-24.—Position of diestock in relation to chamfer on end of work.


BACK ONE QUARTER TURN
ONE QUARTER TURN
ONE QUARTER TURN
LARD OIL AND WHITE LEAD 50-50

11.5.4C

Figure 6-25.—Cutting outside threads on round stock.

indicates that a class 1 fit is required. A class 1 fit is a loose fit. The fit is controlled while threading the round stock. We tap the threads in the hole first as there is no way to adjust a tap. However, as threading dies are usually adjustable, we can control the fit of the threaded rod in the tapped hole by adjusting the threading die.

The adjustable round split die shown in figure 6-22 has an adjusting screw at A. By tightening this screw and spreading the die slightly, it will cut less deeply into the rod and the fit in the tapped hole will be tighter. The shallow hole at B is placed in the die stock opposite the adjustable handle E and serves as a drive hole. Also, when the adjustable handle is tightened, it holds the split die together and against the adjusting screw to maintain the setting while the die is cutting. The threads or cutting teeth of the die are chamfered or relieved at C to help start the die squarely on the round stock. The die is put into the die stock with the face with the unchamfered teeth against the shoulder, D.

Figure 6-23 is a plain round split die and die stock. At A, where the die is split, there is no adjusting screw. There are shallow holes at B and C, on both sides of the split, opposite which there are setscrews in the die stock at D and E. F is the adjusting screw which is pointed and enters the split A in the die. D and E are the holding setscrews. They have flat points and are tightened after the setting is made with F. D and E hold the adjustment and furnish the drive as they enter the shallow holes B and C shown in figure 6-23.

Figure 6-24 shows a section of the die in the die stock and its relation to the chamfer on the end of the work. The taper on the face of the die will accept the chamfer on the end of the work to start the threads square with the common center line.

To thread the work, brush some 50-50 white lead and lard oil on the rod. Start the die square with the work. Hold one handle with each hand, apply downward pressure, and turn clockwise until you feel the thread has been started. When the die has started to cut, rotate the die stock two quarter turns, back it off one quarter turn to break the chips, and repeat the cutting (fig. 6-25). When you have cut enough threads so that the rod comes through the back of the die, remove the die and try the rod in the tapped hole.

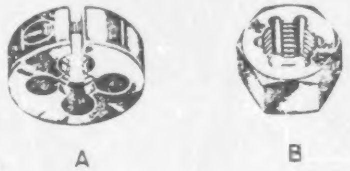
Adjusting a threading die to produce a thread of the proper fit is a trial-and-error procedure. This was a trial run. If the fit is too loose, cut off and discard the portion of the rod that you threaded. Then expand the die by tightening the pointed setscrews (or the adjusting screw) so that the die will cut shallower threads on the rod and produce a tighter fit.

If the fit is too tight, it will not be necessary to discard the threaded portion of the rod. Contract the die by backing off (loosening) the pointed setscrew (or the adjusting screw) to decrease the size of the split in the die. This will cause the die to remove more metal, when cutting, and produce a looser fit. Then run the die down the cut threads that were too tight. Now test the fit again by turning the threaded end into the tapped hole.

When you have finished the threading job, remove the die from the die stock, carefully clean out all the loose chips, and apply plenty of oil. Wipe off the surplus oil and put the die and die stock away in the threading set where it will be protected and ready for the next job.

RECONDITIONING MACHINE THREADS

To recondition machine threads, when the damage is not serious, the general practice is to select the proper threading die, one type of which is shown in figure 6-26A. Start the die with the chamfered face of the die which is shown in the figure. Put it in a die stock, and run over the threads that are damaged. For steel, lubricate with a 50-50 mixture of white



44.151

Figure 6-26.—Two thread reconditioning tools.

44.152

Figure 6-27.—Thread restorer.

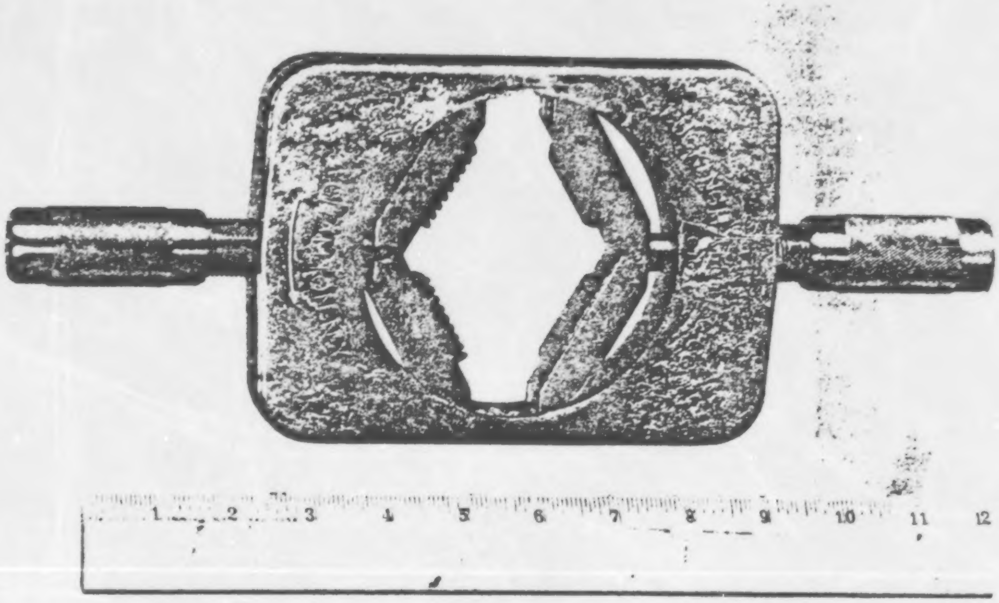


Figure 6-28.—Adjustable thread restorer. 44.153X

lead and lard oil, lard oil alone, or lubricating oil if the others are not available. Use no lubricant for brass and copper.

The screw and bolt rethreading die, shown in figure 6-26B, is designed especially for reconditioning threads. The six sets of cutting teeth, in place of the customary four sets on a threading die, provide better alignment while the die is recutting damaged threads. Turn this rethreading die with any type of wrench or hold the die in a vise and turn the threaded piece through it.

When only the first thread or the first 2 or 3 threads are damaged, and a perfect thread is not absolutely necessary, a three-square file can be used to touch up the tops of the damaged threads.

The thread restorer shown in figure 6-27 resembles a square file. Each face is designed to match a certain pitch-screw thread. Two sizes of this tool are available, each one covering eight different machine-thread pitches. Together they cover a range of from 9 threads per inch through 32 threads per inch. Use this thread restorer as you would a file, maintaining the proper angle (that of the threads) as you go over the damaged threads.

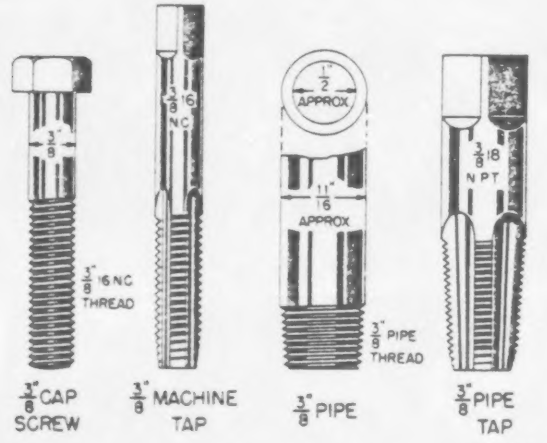
Tools of this type are available for external pipe threads as well as for machine threads. The thread restorer for internal pipe threads, however, is similar to a tap. This type of thread restorer, whether internal or external, removes metal. Therefore, the thread that remains as a restored thread will not be a perfect or full thread. Where the crest of the original thread was battered over, the crest of the restored thread will be noticeably flat. Threads restored in this manner are, for practical purposes, as strong as new threads and will again enter a nut or tapped hole.

Another type of thread restorer is shown in figure 6-28. This tool is not designed to cut new threads, but only as a maintenance and repair tool. Its action is a reforming action and not a cutting action. Therefore no metal is removed from the thread that is being forced back to its original shape.

Only four sizes of this tool are necessary to cover thread diameters from one-quarter inch to 6 inches. A fifth size takes all diameters from 6 to 12 inches, inclusive. Each size will fit any pitch, left- or right-hand threads, standard pipe or machine thread, within the size limits specified, and no change of blades or dies is necessary. This restorer will not work on Acme threads.

To operate this thread restorer, simply slip it over the threads with the arrow on top, or toward you. Then tighten the jaws or blades to a snug fit into the threads close to the back of the thread where no damage has been done. Then, just as you would remove a nut, turn the tool counterclockwise in the direction of the arrow on right-hand threads. To restore left-hand threads, first flop the tool over so that the face of the tool having the arrow is away from you. Then, after bringing the jaws up snug, run the tool off of the left-hand threads by turning it clockwise so that it will move toward you. Notice that this type of thread restorer normally works from the bottom or back of the thread out toward the end, restoring the threads as it progresses.

In most cases, resotrers slide easily over key ways and milled flats on threaded parts. It may be found that the milled flat is rather wide on large-diameter jobs. In such cases threads can still be restored and the tool will negotiate the flat if you will clamp a half round piece of soft wood on the flat and operate the tool as directed. When this is necessary, it is usually on work of 2-inch diameter or larger. When used on studs or bolts having cotter pin holes, a small wooden plug in the hole will avoid breaking teeth. Keep the restorer clean and well oiled both in use and in storage.



44.154

Figure 6-29.—Comparison of machine thread tap and pipe thread tap.

CUTTING INTERNAL PIPE THREADS

Pipe threads are tapered threads to provide an airtight and liquidtight joint. A 3/8" machine thread tap and a 3/8" pipe thread tap are compared in figure 6-29 show their differences. The 3/8" machine thread tap will cut machine threads in a hole so that a 3/8" cap screw, having the same thread can be screwed into the hole. The 3/8" pipe thread tap will cut pipe threads in a hole so that a 3/8" threaded pipe can be screwed into the hole. Because pipe diameters are measured and given as inside diameters, and the wall thickness of the pipe must be taken into consideration, the 3/8" pipe thread tap in figure 6-29 is noticeably larger than the 3/8" machine thread tap. It should also be noted that the pipe thread tap is tapered, but the machine thread tap is not.

The N.P.T., which formerly stood for National Pipe Thread, is still used as a carryover and now refers to the new name for the same thread, American Standard Taper Pipe Thread. This standard taper is 3/4" per foot.

To select the proper tap drill for the pipe tap that you will use to tap a hole to take a given size of threaded pipe, refer to table 6-3. For example, if you want to drill and tap a hole to take a 3/8" pipe thread, find the 3/8" pipe tap in the Pipe Tap Size column. Opposite this, in the Tap Drill Size column, is 19/32", the proper tap drill to use for a 3/8" pipe tap.

To cut internal pipe threads, drill a tap hole in the stock to be tapped and, following the suggested procedure for tapping machine threads described earlier in the chapter under the heading Cutting Machine Threads With Taps,

Table 6-3.—American Standard Pipe Tap Drill Sizes

44.155

PIPE TAP SIZE	TAP DRILL SIZE	PIPE TAP SIZE	TAP DRILL SIZE
1/8	11/32	2	2 3/16
1/4	7/16	2 1/2	2 5/8
3/8	19/32	3	3 1/4
1/2	23/32	3 1/2	3 3/4
3/4	15/16	4	4 1/4
1	1 5/32	4 1/2	4 3/4
1 1/4	1 1/2	5	5 5/16
1 1/2	1 23/32	6	6 3/8

770

run the pipe tap into the tap hole. Notice that the first few threads on the pipe tap are ground away. This makes starting easier. Plenty of lard oil is the standard lubricant for steel. Tap copper and brass with no lubricant. The depth to which it is desirable to tap pipe threads is usually determined by turning the threaded pipe into the tapped hole for a trial. As shown in figure 6-30, the last few threads on the pipe should still be visible when the pipe is drawn up tight in the tapped hole. Figure 6-30 shows the values of dimension A (the length of thread on pipe required to make a tight joint) for various sizes of pipe up to 12".

The general practice in tapping holes for pipe threads is to drill the proper size tap hole and then start the pipe tap right into the tap hole. Some men recommend using a pipe reamer, especially when large deep holes are to be tapped. A pipe reamer has the same 3/4" per foot taper as a pipe tap. A reamed pipe tap hole would have the same shape as the pipe tap, and therefore would make tapping easier and reduce wear on the tap.

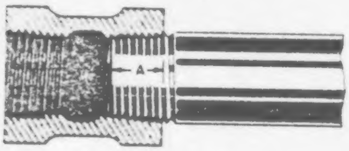
CUTTING EXTERNAL PIPE THREADS

Usually, both ends of a pipe are threaded with external pipe threads. Notice, in all the figures showing pipe threads, that they are V-shaped. The standard 3/4" taper per foot of pipe threads is equal to 1/16" per inch. Therefore, the taper of the threads on each side of the pipe is 1/32" taper per inch. This taper cannot be changed. This produces a tight joint. The angle between sides of the threads is 60°, and several threads on the end of the pipe are perfect threads. The next few have V-bottoms but flat tops, and the last few threads have both flat tops and bottoms. Each size of pipe has a certain number of threads per inch, built into the pipe taps and dies.

Adjustable pipe dies have a reference mark on each die which, when lined up with the corresponding reference mark on the die stock, will give a standard-size thread. You adjust the dies one way or the other from the reference mark to cut a thread with the fit you want.

To cut external threads on iron pipe, first determine its nominal size. Nominal size means the "name size" of the pipe such as 1/8", 3/4", and so on. Except in the sizes below 1", nominal sizes correspond closely to inside diameters. For 1" pipe and larger, measure the inside diameter (I.D.) with your rule, to the closest 1/32", and you will have nominal size. For sizes below 1", you can determine nominal size by measuring the outside diameter (O.D.) to the nearest 1/32" and reading the corresponding nominal size in Table 6-4. This method can also be employed for sizes 1" and above in lieu of the I.D. measurement.

To begin cutting, put the die stock on the pipe so that the pipe passes through the guide and enters the tapered face of the pipe die. Turn the die stock clockwise for right-hand



Size of Pipe, Inches	Dimension A, Inches	Size of Pipe, Inches	Dimension A, Inches	Size of Pipe, Inches	Dimension A, Inches
1/8	1/4	1½	11/16	5	1¼
1/4	3/8	2	3/4	6	1 5/16
3/8	3/8	2½	15/16	7	1 3/8
1/2	1/2	3	1	8	1 7/16
3/4	9/16	3½	1 1/16	9	1½
1	11/16	4	1 1/8	10	1 5/8
1¼	11/16	4½	1 3/16	12	1¾

44.156

Figure 6-30.—Length of thread on pipe required to make a tight joint.

Table 6-4.—Approximate O.D. of Standard Wrought Iron Pipe

44.157

Nominal Size	Outside Diameter	Nominal Size	Outside Diameter
1/8	13/32	3½	4
1/4	17/32	4	4½
3/8	11/16	4½	5
1/2	27/32	5	5 9/16
3/4	1 1/16	6	6 5/8
1	1 5/16	7	7 5/8
1¼	1 21/32	8	8 5/8
1½	1 29/32	9	9 5/8
2	2 3/8	10	10¾
2½	2 7/8	11	11¾
3	3½	12	12¾

1121

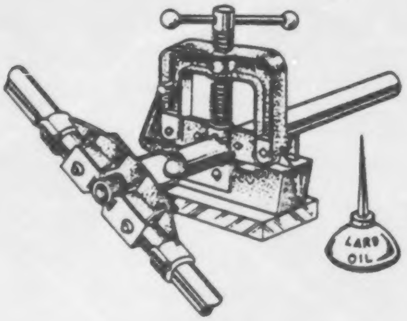
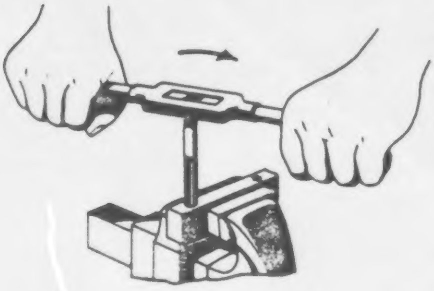


Figure 6-31.—Threading an external pipe thread with a pipe die. 11.3.4

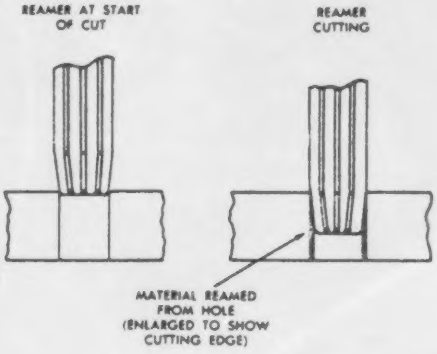


44.158

Figure 6-32.—Using a tap wrench to turn a hand reamer.

threads, applying pressure only when starting. It is not necessary to turn the die back and forth as you do when cutting machine threads. Pipe-threading dies can cut continuously because they cut only as many threads on the pipe as there are on the die itself and because there is plenty of room in a pipe die for the chips to escape. After the die has taken hold, it will feed itself. When cutting threads on steel pipe, apply lard oil to the pipe and die where the cutting is actually taking place. Continue turning until the end of the pipe has gone through the die and is flush with the near face. See figure 6-31.

This will give you the length of thread called for in the table in figure 6-30. Notice that, in the assembled pipe joint in figure 6-30 several threads remain on both pipe and fitting to permit further tightening should a leak develop.



44.159

Figure 6-33.—Reaming a hole with a straight hole reamer.

Table 6-5.—Standard Taper Pin Dimensions

44.160

No. of Pin	Diameter at Large End		Max. Length
	D	D	L
00000	0.094	3/32	3/4
0000	.109	7/64	7/8
000	.125	1/8	1
00	.141	9/64	1 1/8
0	.156	5/32	1 1/4
1	.172	11/64	1 1/4
2	.193	3/16	1 1/2
3	.219	7/32	1 3/4
4	.250	1/4	2
5	.289	19/64	2 1/4
6	.341	11/32	3
7	.409	13/32	3 3/4
8	.492	1/2	4 1/2
9	.591	19/32	5 1/4
10	.706	23/32	6
11	.860	55/64	7 1/4
12	1.032	1 1/32	9
13	1.241	1 15/64	11
14	1.523	1 33/64	13

REAMING OPERATIONS

Reaming operations are jobs that smoothly enlarge drilled holes to an exact size and finish the hole at the same time. A hole that has been made by drilling is usually slightly oversize. This is quite satisfactory for holes in which bolts or rivets are placed. When greater accuracy and a smooth finish are required, the hole is first drilled undersize and then finished

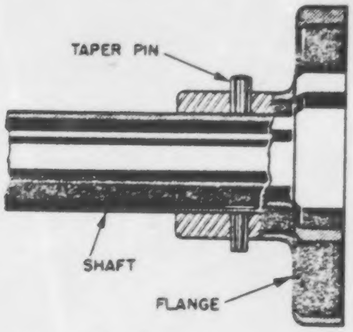


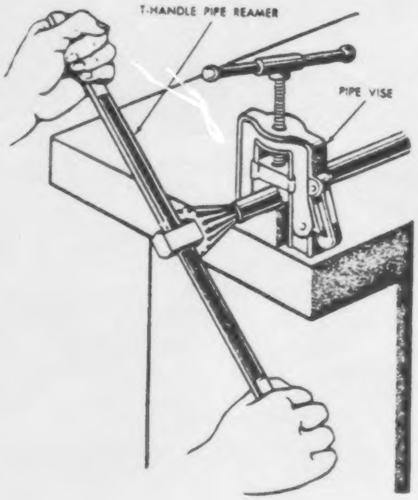
Figure 6-34.—A tapered pin installed in a shaft and flange.

44.161

Table 6-6.—Taper Reamer Dimensions

44.162

No. of Taper Pin Reamer	Diameter at Large End of Reamer	Diameter at Small End of Reamer	Length of Flute
7/0	0.0666	0.0497	13/16
6/0	0.0806	0.0611	15/16
5/0	0.0966	0.0719	1 3/16
4/0	0.1142	0.0869	1 5/16
3/0	0.1302	0.1029	1 5/16
2/0	0.1462	0.1137	1 9/16
0	0.1638	0.1287	1 11/16
1	0.1798	0.1447	1 11/16
2	0.2008	0.1605	1 15/16
3	0.2294	0.1813	2 5/16
4	0.2604	0.2071	2 9/16
5	0.2994	0.2409	2 13/16
6	0.3540	0.2773	3 11/16
7	0.4220	0.3297	4 7/16
8	0.5050	0.3971	5 3/16
9	0.6066	0.4805	6 1/16
10	0.7216	0.5799	6 13/16



11.3.4A

Figure 6-35.—Using a pipe reamer to remove burrs from pipe.

by reaming. Reamers are also used to remove burrs from the insides of pipe.

STRAIGHT HOLES

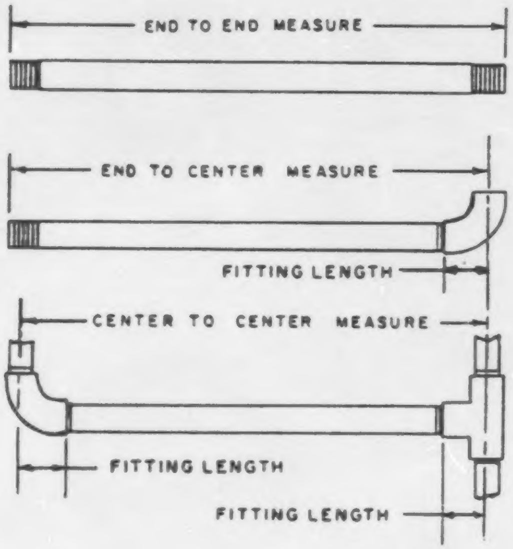
A solid straight-hole reamer is used for most work, since it is the most accurate and rugged reamer. The straight-hole handreamer is turned by means of a tap wrench that is tightened on the square end of the reamer shank. (See fig. 6-32.) Secure the work in a vise so that the hole to be reamed is perpendicular to the top of the vise jaws. Position the reamer at the top of the hole (fig. 6-33). Straight-hole reamers have a slight taper at the end so that they will fit into the hole easily. Turn the wrench clockwise very slowly until the reamer is centered in the hole.

After the reamer is centered in the hole, turn the wrench clockwise with a steady firm pressure until the reamer has been turned all the way through the hole. When reaming steel, use cutting oil or machine oil to lubricate the tool. When reaming soft iron, do not lubricate the tool. To remove the reamer from the hole turn the wrench clockwise and raise the reamer simultaneously.

NOTE: Turning the wrench too fast or too slowly will cause the reamer to chatter, producing an unevenly reamed hole.

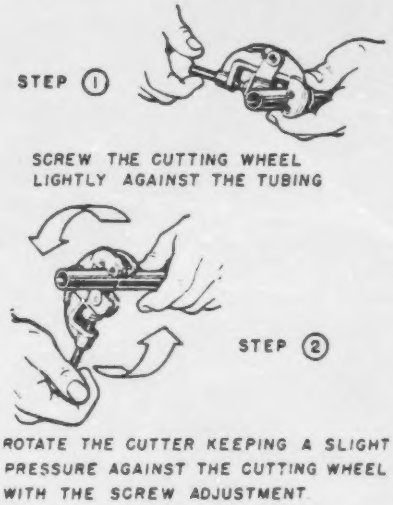
TAPERED HOLES AND PIN INSTALLATION

To install a tapered pin, refer to the blueprint or drawing for the proper size of pin to



11.335(44)

Figure 6-36.—Proper methods for measuring pipe to desired lengths.

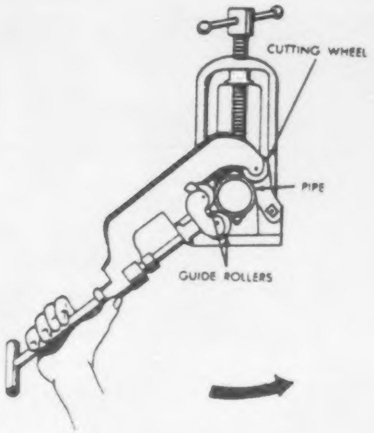


SCREW THE CUTTING WHEEL LIGHTLY AGAINST THE TUBING

ROTATE THE CUTTER KEEPING A SLIGHT PRESSURE AGAINST THE CUTTING WHEEL WITH THE SCREW ADJUSTMENT

44.164X

Figure 6-38.—Steps in cutting tubing with a tube cutter.



29.205

Figure 6-37.—Cutting pipe with a pipe cutter.

use. The size will be given as a number and length in inches (table 6-5). For instance, a No. 3 pin 1 3/4" long might be specified. Then, when you have the proper pin, measure the diameter of its small end and drill a hole of that size through for example, the hub of a flange and a shaft while the flange is in place on the shaft. (See fig. 6-34.) Then select the same number of tapered pin reamer, a No. 3 in this case.

Table 6-6 shows specifications of various sizes of reamers. The specifications given opposite the reamer numbers in the left-hand column of table 6-6 are the dimensions of the reamers. The small end of the reamer should just enter the hole you drill and, if the proper size of reamer has been selected, the pin will fit exactly. Turn the tapered pin reamer with a tap wrench slowly and in a clockwise direction only, lifting it out of the hole to clean away the chips while it is still turning. If you reverse the direction of the reamer, chips may be wedged behind its cutting edges, causing them to break. Ream brass dry but apply cutting oil liberally when reaming steel. Try the taper pin in the hole several times as the reaming progresses. Stop reaming when the pin protrudes the same amount on both sides of the hub of the gear.

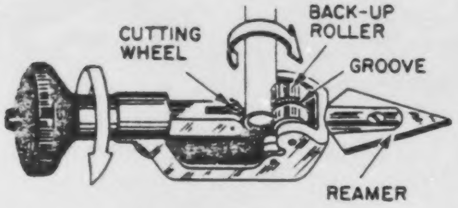
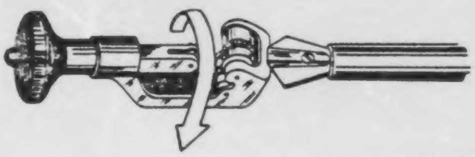


Figure 6-39.—Cutting tubing close to the base of a flare. 44.165



44.166X
Figure 6-40.—Reaming the burrs from a piece of tubing.

BURR REMOVAL

After a piece of pipe has been cut, the ends should be reamed to remove the burr that is left on the inside of the pipe. This burr, if not removed, will restrict the flow of fluid in the pipe. Besides the pipe reamer you will need a vise to hold the pipe steady. After making sure the pipe is held firmly in the vise, insert the reamer in the end of the pipe and turn the handle. (See fig. 6-35.) Rotate the handle of the reamer clockwise in short even strokes until the burrs inside the cut piece of pipe are completely removed. Remove the reamer from the pipe by rotating it clockwise and reducing applied pressure.

CUTTING PIPING AND TUBING

In performing certain tasks, you may be required to cut pipe or tubing. The main difference between pipe and tubing lies in their wall thicknesses; pipe has thicker walls than tubing. Though pipe cutters are larger than tube cutters, they work on the same principle.

PIPE

You will probably cut more pipes made of iron than any other metal. These pipes must be cut to specific lengths. Before cutting a pipe to length, make sure you have the correct measurement. Figure 6-36 shows three methods of measuring threaded pipe to desired lengths.

The end-to-end method includes measuring the threaded portions of the pipe and measuring the pipe from end to end. The end-to-center method is used on a section of pipe that has a fitting screwed on one end only; measure from the free end of the pipe to the center of the fitting at the other end of the pipe. The center-to-center method is used when both ends of the pipe have fittings; measure from the center of one fitting to the center of the other fitting at the opposite end of the pipe.

The approximate length of thread on 1/2- and 3/4-inch wrought iron or steel pipe is 3/4 inch. On 1-, 1 1/4-, and 1 1/2-inch pipe, it is approximately 1 inch long. On 2- and 2 1/2-inch pipe, the length of thread is 1 1/8 and 1 1/2 inches respectively.

To determine the length of pipe required, take the measurement of installation such as center to center of the pipe requiring two fittings. Measure the size of the fittings as shown in figure 6-36. Subtract the total size of the two fittings from the installation measurement. Multiply the approximate thread length by 2 and add the result to the length obtained. This will give the length of pipe required.

After the length of the pipe has been determined, measure the pipe and mark the spot where the cut is to be made with a scriber or crayon. Lock the pipe securely in a pipe vise.

Inspect the cutter to make sure that there are no nicks or burrs in the cutting wheel. Open the jaws of the cutter by turning the handle counterclockwise. Position the cutter around the pipe at the marked point. Make sure the cutting wheel is exactly on the mark and close the jaws of the cutter lightly against the pipe by turning the cutter handle clockwise. After making contact, turn the cutter handle clockwise one-fourth of a turn more. This will put a bite on the pipe.

Grasp the cutter handle and rotate the cutter as a whole one complete revolution, swinging it around the pipe in the direction indicated in figure 6-37. Turn the cutter handle clockwise one-fourth of a turn more to take another bite on the pipe and rotate the cutter another complete revolution. Keep the cutter perpendicular to the pipe at all times or the wheel will not track properly. Repeat this operation until the pipe is cut. Remove the small shoulder on the outside of the pipe with a file and remove the burr on the inside with a reamer.

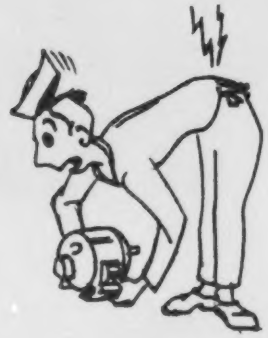
TUBING

Copper tubing is one kind of metallic tubing that you can cut readily with a tube cutter. To cut tubing, place the tube cutter with the cutting wheel on the mark where the cut is to be made. Move the cutting wheel into light contact with the tubing. See step 1 in figure 6-38. Then swing the handle around the tubing as you feed the cutting wheel a little for each revolution by turning the screw adjustment. Different wall thicknesses, kinds, and diameters of metallic tubing require different feeds. Step 2, figure 6-38, indicates the direction of rotation. The feed pressure is correct when it keeps the wheel cutting but does not flatten the tubing.

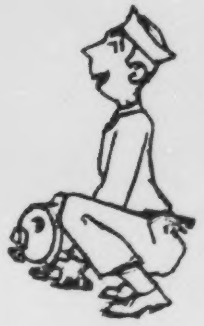
The design of some tubing cutters will permit cutting off a flared end close to the base of the flare. In figure 6-39, notice the groove in the backup roller. Place the flare in this groove so that the cutting wheel rides at the base of the flare. Then cut off the flare as you would cut tubing.

Burrs that form may be similar to those formed in pipe cutting. Remove the inside burr with the reamer attached to the tubing cutter opposite the handle (fig. 6-40). In some cases a three-cornered scraper, pocketknife blade, or round file may work better than the reamer. After reaming clean out the chips. Then remove any outside burr with a file.

SAFETY



DON'T LIFT MOTORS WITH YOUR BACK



LIFT MOTORS WITH YOUR LEGS
KEEP YOUR BACK STRAIGHT

CHAPTER 7

MISCELLANEOUS TASKS

Navy personnel are required to have, or develop, the skill or ability to perform various tasks that differ from those previously discussed in this manual. This chapter describes the tools, procedures, and techniques that personnel must use to become proficient when performing miscellaneous tasks such as bending and flaring tubes, removing broken bolts and studs, stripping wire, and soldering.

BENDING AND FLARING METALLIC TUBING

The objective in tube bending is to obtain a smooth bend without flattening the tube. Tube bending is usually accomplished with one of the tube benders discussed in this chapter. In an emergency, however, aluminum tubing under one-fourth of an inch in diameter may be bent by hand.

SPRING BENDERS

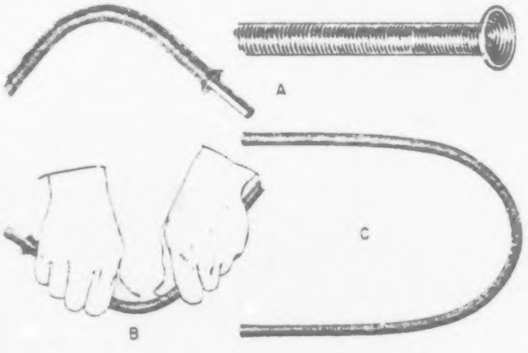
External spring-type benders, shown in figure 7-1A, come in sizes to bend 1/4", 5/16", 3/8", 7/16", 1/2", and 5/8" outside-diameter soft copper, aluminum, and other soft metallic tubing. To bend tubing with this type of bender, first select the size that will just slip over the size of tubing you want to bend. Then slip it over the tubing so that it centers at the middle of the proposed bend. Grasp the bender with both hands and make the bend. (See fig. 7-1B.) The restraining action of the bender will prevent the tubing from collapsing at the bend and will produce a smooth curve. To remove the bender, grasp the belled end and pull it off the tubing.

Internal spring-type benders, shown in figure 7-1C, come in sizes to bend 3/8", 1/2", and 5/8" outside diameter tubing. This type can be used when both ends of a length of tubing are flared and the external type cannot be applied. To bend tubing with an internal spring-type bender, select the proper size bender and slip it inside of the tubing. Insert it so that the center of its length is at the center of the proposed bend. Grasp the tubing with both hands and make the bend. If the bender sticks out of the end of the tubing, remove it by pulling it out. If not, remove it with a fish wire or other simple means.

HAND TUBE BENDER

The hand tube bender shown in figure 7-2 consists of four parts—handle, radius block (mandrel), clip, and slide bar. The radius block is marked in degrees of bend ranging from 0 to 180. The slide bar has a mark which is lined up with the zero mark on the radius block. The tube is inserted in the tool, and after lining up the marks, the slide bar is moved around until the mark on the slide bar reaches the desired degrees of bend on the radius block. Follow the procedure indicated in figure 7-2.

This type of bender is furnished in 3/16", 1/4", 5/16", 3/8", and 1/2" sizes. For larger sizes of tubing similar mandrel-type benders are used. The only difference is that these larger benders are geared for greater mechanical advantage.



44.185X

Figure 7-1.—Bending tubing with spring type tube benders.

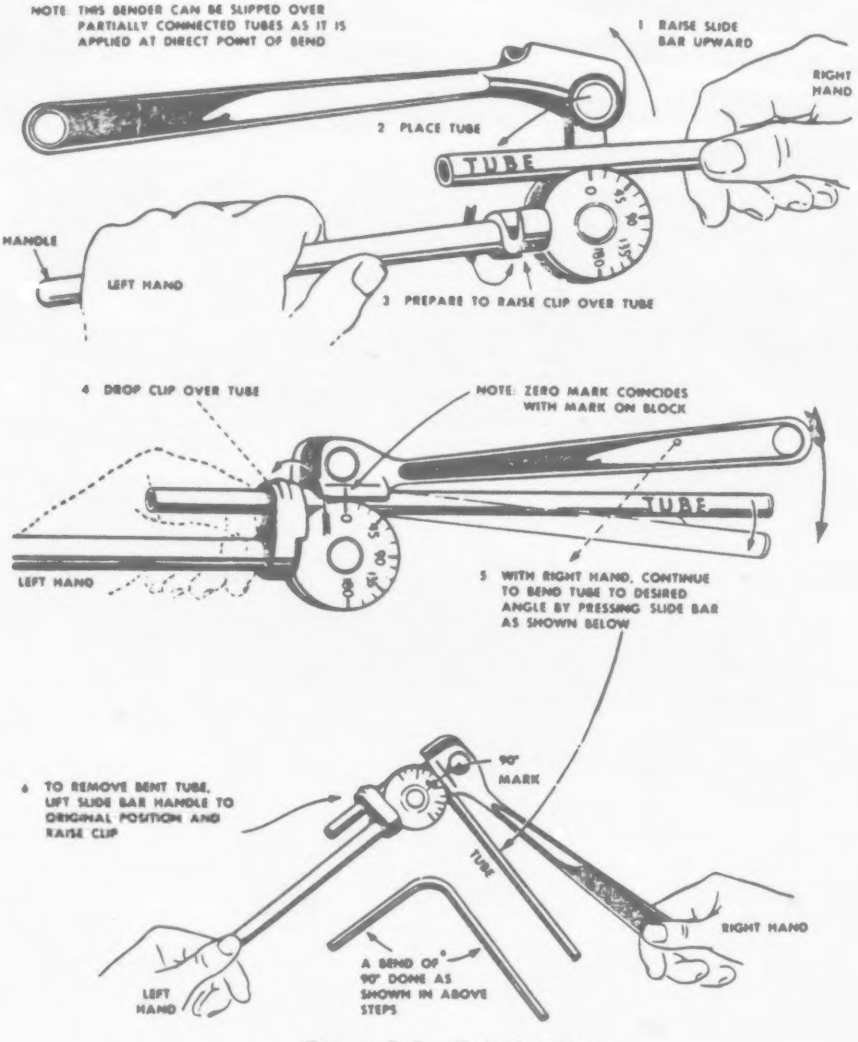

NOTE: THIS BENDER CAN BE SLIPPED OVER PARTIALLY CONNECTED TUBES AS IT IS APPLIED AT DIRECT POINT OF BEND
1 RAISE SLIDE BAR UPWARD
RIGHT HAND
2 PLACE TUBE
TUBE
0
45
90
135
180
HANDLE
LEFT HAND
3 PREPARE TO RAISE CLIP OVER TUBE
4 DROP CLIP OVER TUBE
NOTE: ZERO MARK COINCIDES WITH MARK ON BLOCK
TUBE
LEFT HAND
5 WITH RIGHT HAND, CONTINUE TO BEND TUBE TO DESIRED ANGLE BY PRESSING SLIDE BAR AS SHOWN BELOW
6 TO REMOVE BENT TUBE, LIFT SLIDE BAR HANDLE TO ORIGINAL POSITION AND RAISE CLIP
90° MARK
TUBE
RIGHT HAND
LEFT HAND
A BEND OF 90° DONE AS SHOWN IN ABOVE STEPS

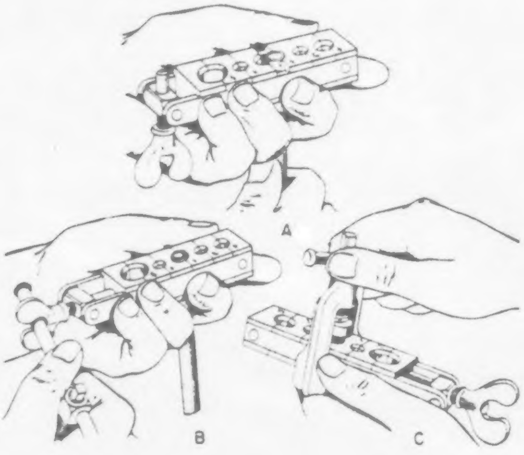
Figure 7-2.—Tube bending.

11.163

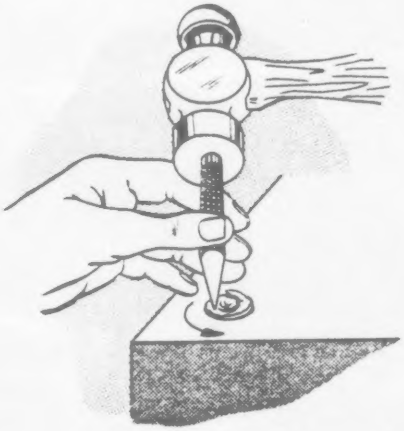
FLARING

Tube flaring is a method of forming the end of a tube into a funnel shape so that it can be held by a threaded fitting. A partially threaded flare nut is slipped over the tube, the end of the tube is flared, the flare is seated with the inside of the flare against the end of a fitting which has threads on the outside, and then the flare nut is screwed onto the fitting, pushing the outside of the flare against the seating surface of the fitting.

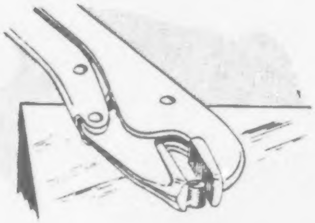
The tube-flaring tool shown in figure 7-3 is one type which is commonly used to flare copper tubing. To flare the end of tubing, first check to see that it has been cut off squarely and has the burrs removed from both inside and outside. Remember to slip the flare nut on the tube before you make the flare. Then, as shown in figure 7-3A, open the flaring tool at the die which corresponds to the size of the tubing being flared. Insert the end of the tubing to protrude slightly above the top face of the die blocks. The amount by which the tubing extends



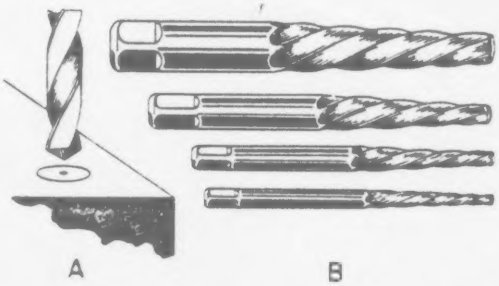
44.186X
Figure 7-3.—Flaring metallic tubing.



44.188
Figure 7-5.—Removing a broken bolt with a prick punch.



1.21C
Figure 7-4.—Removing a broken stud with vise-grip pliers.



44.20BB.2
Figure 7-6.—Screw and bolt extractors for removing broken studs.

above the blocks determines the finished diameter of the flare. The flare must be large enough so that it will seat properly against the fitting, but small enough so that the threads of the flare nut will slide over it. You determine the correct size by trial-and-error. Then as shown in figure 7-3B, close the die block and secure the tool with the wing nut. Use the handle of the yoke to tighten the wing nut. Then place the yoke over the end of the tubing (fig. 7-3C), and tighten the handle to force the cone into the end of the tubing. The completed flare should be slightly visible above the face of the die blocks.

REMOVING BROKEN BOLTS AND STUDS

When the removal of a broken bolt or stud is required, flood the part being worked on with plenty of penetrating oil or oil of wintergreen. Time permitting, soak the area for several hours or overnight. A week's soaking may loosen a bolt which would otherwise have to be drilled out.

If enough of the broken piece protrudes take hold of it with vise-grip pliers, as shown in

Table 7-1.—Chart for Screw and Bolt Extractors 44.220

Extractor		Used For—		Use Drill Size Dia., Inches
Size No.	Overall Length, Inches	Nominal Screw And Bolt Size, Inches	Nominal Pipe Size, Inches	
1	2	3/16 - 1/4	--------	5/64
2	2 3/8	1/4 - 5/16	--------	7/64
3	2 11/16	5/16 - 7/16	--------	5/32
4	3	7/16 - 9/16	--------	1/4
5	3 3/8	9/16 - 3/4	1/4	17/64
6	3 3/4	3/4 - 1	3/8	13/32
7	4 1/8	1 - 1 3/8	1/2	17/32
8	4 3/8	1 3/8 - 1 3/4	3/4	13/16
9	4 5/8	1 3/4 - 2 1/8	1	1 1/16
10	5	2 1/8 - 2 1/2	1 1/4	1 5/16
11	5 5/8	2 1/2 - 3	1 1/2	1 9/16
12	6 1/4	3 - 3 1/2	2	1 15/16

figure 7-4, and carefully try to ease it out. If the bolt cannot be turned, further soaking with penetrating oil may help. Or try removing the pliers and jarring the bolt with light hammer blows on the top and around the sides. This may loosen the threads so that the bolt can then be removed with the vise-grip pliers.

If a bolt has been broken off flush with the surface as shown in figure 7-5, it is sometimes possible to back it out with light blows of a prick punch or center punch. However, if the bolt was broken due to rusting, this method will not remove it. If it cannot be removed by careful punching first on one side and then the other, a screw and bolt extractor may remove it. (See fig. 7-6B.)

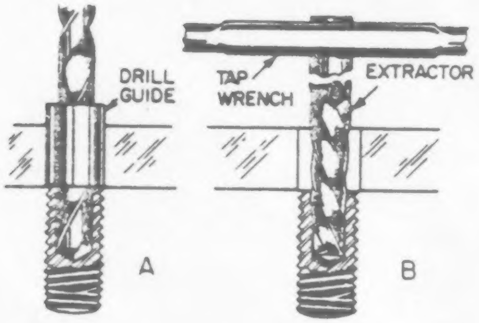
When using this extractor, file the broken portion of the bolt to provide a smooth surface at the center for a punch mark, if possible. Then carefully center punch the exact center of the bolt. (See fig. 7-6A.)

Refer to table 7-1 to select the proper drill size to use according to the size of the broken bolt that you are trying to remove. If possible, drill through the entire length of the broken bolt. Then carefully work some penetrating oil through this hole so that it fills the cavity beneath the bolt and has a chance to work its way upwards from the bottom of the bolt. The more time you let the penetrating oil work from both ends of the broken bolt, the better are your chances of removing it.

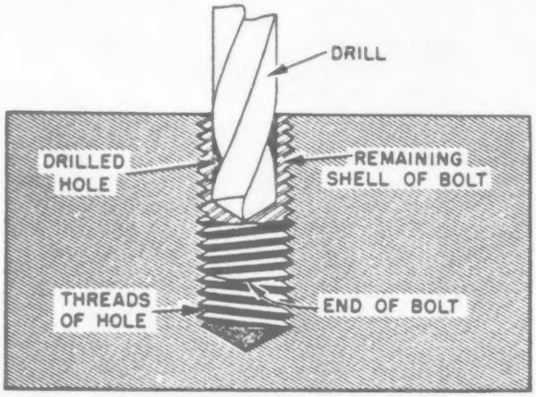
When drilling a hole in a stud which has broken off below the surface of the piece which it was holding, as shown in figure 7-7A, a drill guide will center the drill and may be preferred rather than a center punch mark.

When the hole has been drilled, and additional penetrating oil has had time to soak, put the spiral end of the screw and bolt extractor into the hole. Set it firmly with a few light hammer blows and secure the tap wrench as shown in figure 7-7B. Carefully try to back the broken bolt out of the hole. Turn the extractor counterclockwise. (This type of extractor is designed for right hand threads only.)

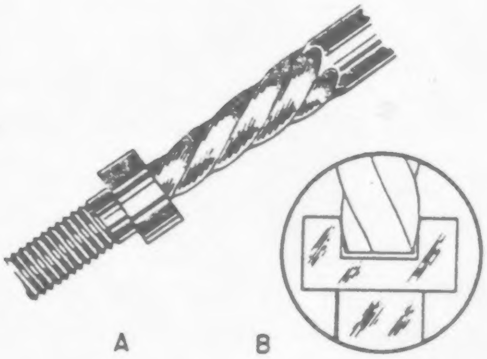
A screw and bolt extractor can sometimes be used to remove an Allen head capscrew when the socket has been stripped by the Allen wrench. (See fig. 7-8.) When attempting this removal, carefully grind off the end of the extractor so that it will not bottom before the spiral has had a chance to take hold. Figure 7-8B shows this end clearance. In doing this grinding operation, great care must be taken to keep the temperature of the extractor low enough so that the tip can be handled with the bare hands. If the hardness is drawn from the



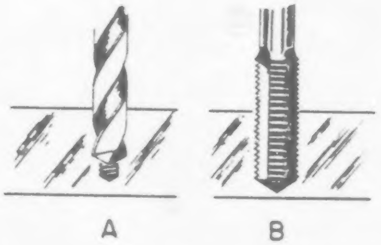
44.20CC
Figure 7-7.—Removing a stud broken off below the surface.



40.20EE
Figure 7-9.—Removing a broken bolt and retapping hole to same size.



44.20DD
Figure 7-8.—Removing an Allen head capscrew with a bolt extractor.



44.189
Figure 7-10.—Removing broken bolt and retapping hole to larger size.

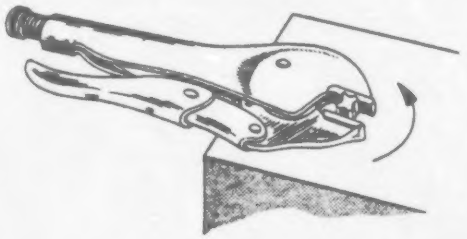
tip of the extractor by overheating during the grinding, the extractor will not take hold.

REMOVING A BROKEN BOLT AND RETAPPING HOLE

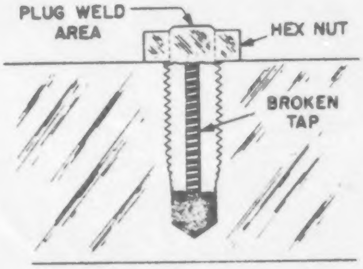
To remove a broken bolt and retap the hole, file the bolt smooth, if necessary, and center-punch it for drilling.

Then select a twist drill which is a little less than the tap-drill size for the particular bolt that has been broken. As shown in figure 7-9, this drill will just about but not quite touch the crests of the threads in the threaded hole or the roots of the threads on the threaded bolt. Carefully start drilling at the center punch mark, crowding the drill one way or the other as necessary so that the hole will be drilled in the exact center of the bolt. The drill in figure 7-9 has almost drilled the remaining part of the bolt away and will eventually break through the bottom of the bolt. When this happens, all that will remain of the bolt will be a threaded shell. With a prick punch or other suitable tool, chip out and remove the first 2 or 3 threads, if possible, at the top of the shell. Then carefully start a tapered tap into these several clean threads and continue tapping until the shell has been cut away and the original threads restored.

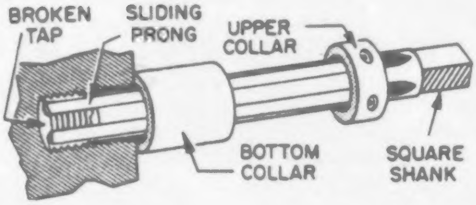
In cases where the identical size of capscrew or bolt is not necessary as a replacement, center-punch and drill out the old bolt with a drill larger than the broken bolt, as shown in figure 7-10A. Tap the hole first, and then



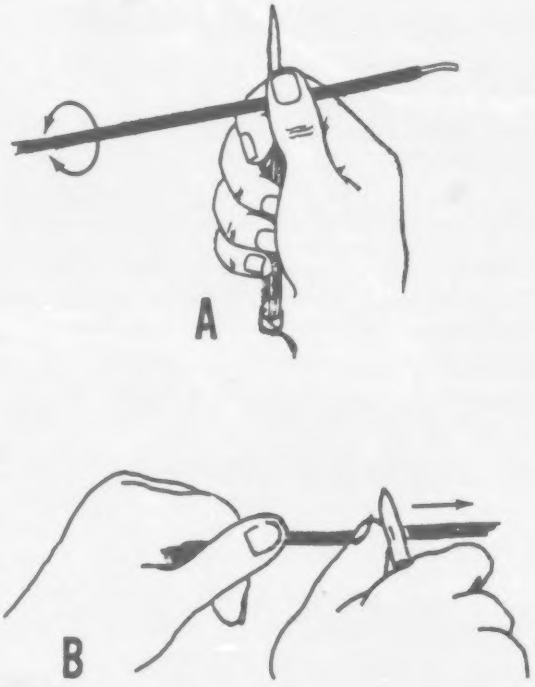
1.21D
Figure 7-11.—Removing a broken tap with vise-grip pliers.



44.192
Figure 7-13.—Using a plug weld to remove a broken tap.



44.191
Figure 7-12.—Removing a broken tap with a tap extractor.



44.184
Figure 7-14.—Stripping insulated wire with a pocket knife.

finish it with a bottoming tap as shown in figure 7-10B. Replace with a larger size capscrew or stud.

REMOVING A BROKEN TAP FROM A HOLE

To remove a broken tap from a hole, generously apply penetrating oil to the tap, working it down through the four flutes into the hole. Then, if possible, grasp the tap across the flats with vise-grip pliers. This operation is shown in figure 7-11. Carefully ease the tap out of the hole, adding penetrating oil as necessary.

If the tap has broken off at the surface of the work, or slightly below the surface of the work, the tap extractor shown in figure 7-12 may remove it. Again, apply a liberal amount of penetrating oil to the broken tap. Place the tap extractor over the broken tap and lower the upper collar to insert the four sliding prongs down into the four flutes of the tap. Then slide the bottom collar down to the surface of the work so that it will hold the prongs tightly against the body of the extractor. Tighten the tap wrench on the square shank of the extractor and carefully work the extractor back and forth to loosen the tap. It may be necessary to remove the extractor and strike a few sharp blows with a small hammer and pin punch to jar the tap

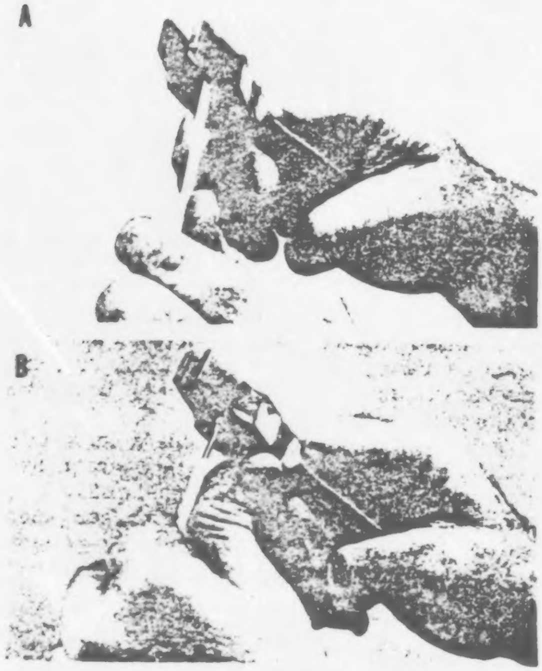
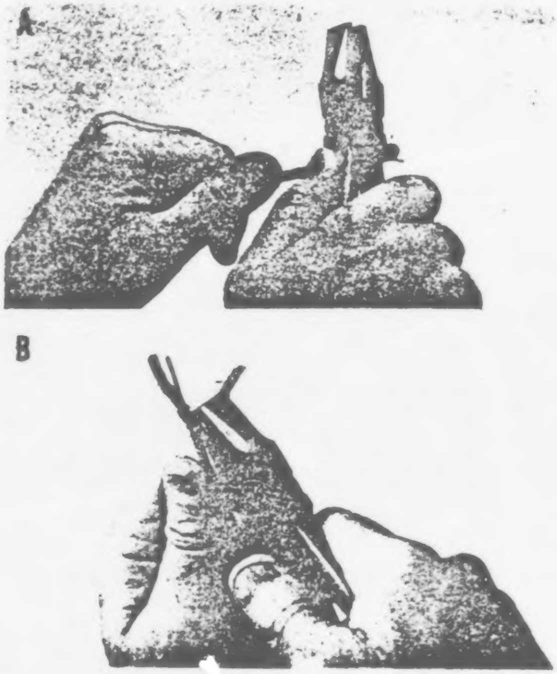


Figure 7-15.—Stripping insulated wire with side cutting pliers. 1.21.8A

loose. Then reinsert the tap remover and carefully try to back the tap out of the hole.

Each size of tap will require its own size of tap extractor. Tap extractors come in the following sizes: 1/4", 5/16", 3/8", 7/16", 1/2", 9/16", 5/8", 3/4", 7/8", and 1".

When a tap extractor will not remove a broken tap, it is often possible to do so by the following method: Place a hex nut over the tap (fig. 7-13), and weld the nut to the tap. Be sure to choose a nut with a hole somewhat smaller than the tap diameter to reduce the possibility of welding the nut and the tap to the job itself. Allow the weld to cool before trying to remove the tap. When the nut, tap, and job have come to room temperature, it is often helpful to heat quickly the immediate area around the hole with an oxyacetylene torch. This quick heat expands the adjacent metal of the work after which the removal of the tap may be less difficult. If the heating is too slow, the tap will expand with the adjacent metal of the work and there will be no loosening effect.



1.21.8B

Figure 7-16.—Stripping insulated wire with side cutting pliers (alternate procedure).

STRIPPING INSULATED WIRE

Insulation may be stripped from wire by using one of several tools. However, a pocketknife or side cutting pliers are generally used for this work.

When using a pocketknife for stripping insulation, hold the wire in one hand and the knife in the other. Use your thumb to roll the wire over the blade of the knife to cut the insulation almost to the wire itself. (See figure 7-14A.) Then pull off or "strip" the short piece of insulation from the end of the wire. Because any nick in the wire will eventually cause a break, it is important not to cut clear through the insulation. By not cutting completely through the insulation, the blade of the knife never comes into contact with the wire itself, thus preventing any possible injury to the surface of the wire. However, cutting nearly through the insulation weakens it sufficiently so that the insulation can be stripped from the wire.

Another way to perform this operation is, while holding the wire in one hand and the pocketknife in the other, hold the wire against the knife blade and cut the insulation off with several strokes of the blade, working around the wire with each successive stroke. (See fig. 7-14B.) Notice that the blade is held almost flat against the insulation. This low angle prevents the blade from cutting into the wire itself.

Insulated wire can be stripped with the side cutting pliers, as shown in figure 7-15, by nicking the insulation all around, being careful not to break through to the wire itself, and stripping the short length of insulation off the end of the wire. Notice that, in figure 7-15A, the man's index finger is wedged between the handles of the pliers close to the joint. This affords better control over the cutting edges so that there is less chance that the insulation will be broken completely through. When the nick has been made all around the wire, press your thumb against the side of the pliers to break the insulation at the nick and, without changing the grip of the pliers, strip it off the end. (See fig. 7-15B.) Care must be exercised to avoid cutting too far through the insulation and nicking the wire.

Insulated solid wire can also be stripped as shown in figure 7-16. Starting at the end of the wire, grip and crush the insulation between the flat places on the inside of the handles close to the hinged joint. In figure 7-16A, the insulation has been crushed and the wire exposed. Then, as shown in figure 7-16B, grasp the insulation close to the end of the crushed portion and tear it off. Although this method leaves a rather ragged appearing end on the remaining insulation, there is no possibility of damaging the wire.

SOLDERING

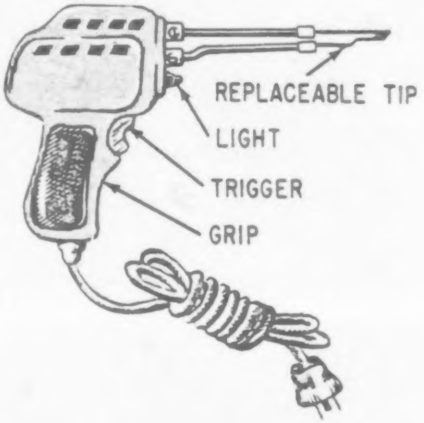
Soldering is a metal-joining process in which a lower melting-point metal (called solder) is heated to the point where it melts and wets the joint surface and then is allowed to solidify in place. To enable the solder to wet the surfaces readily and be drawn into fine cracks, the surfaces and the solder must be clean and free of oxide film. When necessary, the cleaning is done with chemicals or abrasives. One cleaning substance frequently used is called flux. Copper, tin, lead, and brass are examples of readily solderable metals. Galvanized iron, stainless steel, and aluminum are difficult to solder and require the use of special techniques which are beyond the scope of this manual.

Soldering is a practical method of forming reliable electrical connections where bare wires are twisted together or are wound on terminals. Soldering is also used to make tight joints, such as lap seams of sheet metal, and to hold parts together physically. Soldered joints, however, do not support loads for long periods of time as well as welded joints do. Where load support is a governing factor, the usual practice calls for riveting, bolting, or using another means of fastening followed by sealing of the joints with solder.

In soldering the readily solderable metals, you only need the solder, a flux, and a heat source. The following paragraphs will be limited to descriptions of the soldering equipment and procedures required for making reliable electrical connections.

SOLDERS

By definition, solders are joining materials or alloys that melt below 800° F. They are available in various forms—wire, bar, ingot, paste and powder. Solders used for electrical connections are alloys of tin and lead whose



44.54

Figure 7-17.—Electric soldering gun.

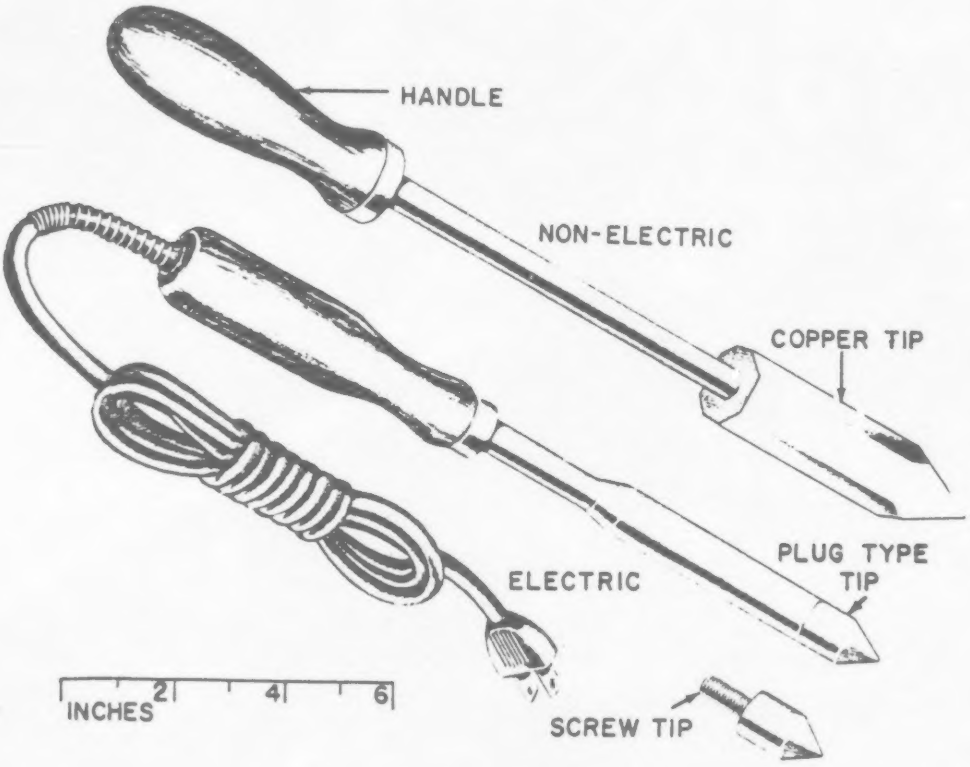


Figure 7-18.—Soldering irons. 11.145:1.26

melting points range between 360° F and 465° F (both endpoints are approximate).

A tin-lead solder alloy is usually identified by two numbers indicating the percentages of tin and lead in the alloy. The first number is the percentage of tin. For example, a 30/70 alloy is made of 30% tin and 70% lead. Likewise, a 15/85 alloy is made of 15% tin and 85% lead. In general, the higher the percentage of tin in a solder alloy, the lower the melting point.

FLUXES

Soldering fluxes are agents which clean solderable metals by removing the oxide film normally present on the metals and also prevent further oxidation. Fluxes are classified as noncorrosive, mildly corrosive, or corrosive, ranging from mild substances such as rosin to chemically active salts such as zinc chloride. Rosin is an effective and nearly harmless flux used for electrical connections that must be reliable, tight, and corrosion free. Rosin flux is available in paste, or powder form for direct application to joints before soldering, or incorporated as the core of wire solders. Unless washed off thoroughly after soldering, salt type fluxes leave residues that tend to corrode metals. Because of their corrosive effects, so-called acid core solders (which incorporate salt-type fluxes) must NOT be used in soldering electrical connections.

SOLDERING TOOLS

The source of heat for melting solder is a soldering gun (electric) or a soldering iron (electric or nonelectric), sometimes called a copper.

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SOLDERING GUN

The soldering gun (fig. 7-17) operates from any standard 115-volt outlet and is rated in size by the number of watts it consumes. The guns used in the Navy are rated between 100 and 250 watts. All good quality soldering guns operate in a temperature range of 500° to 600° F. The important difference in gun sizes is not the temperature, but the capacity of the gun to generate and maintain a satisfactory soldering temperature while giving up heat to the joint soldered. The tip heats only when the trigger is depressed, and then very rapidly. These guns afford easy access to cramped quarters, because of their small tip. Most soldering guns have a small light that is focused on the tip working area.

The tip of a soldering gun should be removed occasionally to permit cleaning away the oxide scale which forms between the tip and metal housing. Removal of this oxide increases the heating efficiency of the gun. If for any reason the tip does become damaged, replaceable tips are available.

NEVER USE a soldering gun when working on solid state equipment. Serious damage to diodes, transistors, and other solid state components can result from the strong electromagnetic field surrounding the tip of the soldering gun.

SOLDERING IRONS

There are two general types of soldering irons in use by the Navy. One is electrically heated and the other nonelectrically heated. The essential parts of both types are the tip and the handle. The tip is made of copper.

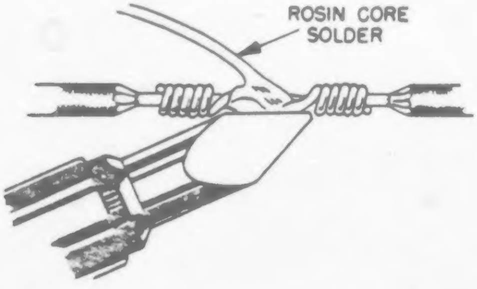
A nonelectric soldering iron (fig. 7-18) is sized according to its weight. The commonly used sizes are the 1/4-, 1/2-, 3/4-, 1-, 1 1/2-, 2-, and 2 1/2-pound irons. The 3-, 4-, and 5-pound sizes are not used in ordinary work. Nonelectric irons have permanent tips and must be heated over an ordinary flame, or with a blowtorch.

The electric soldering iron (fig. 7-18) transmits heat to the copper tip after the heat is produced by electric current which flows through a self-contained coil of resistance wire, called the heating element. Electric soldering irons are rated according to the number of watts they consume when operated at the voltage stamped on the iron. There are two types of tips on electric irons: plug tips which slip into the heater head and, which are held in place by a setscrew, and screw tips which are threaded, and which screw into or on the heater head. Some tips are offset and have a 90-degree angle for soldering joints that are difficult to reach.

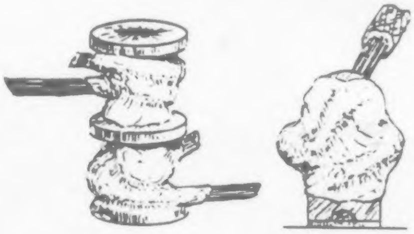
Electric iron tips must be securely fastened in the heater unit. The tips must be clean and free of copper oxide. Sometimes the shaft oxidizes and causes the tip to stick in place. Remove the tip occasionally and scrape off the scale. If the shaft is clean, the tip will not only receive more heat from the heater-element, but it will facilitate removal when the time comes to replace the tip.

TINNING A SOLDERING IRON

If a soldering iron is new or has just been forced, it will need to be tinned (coated with solder). To do so hold it in the vise and "dress" the point with a well-chalked file. By "dressing" is meant filing to remove hammer marks



44.195
Figure 7-19.—Soldering an electrical connection.



83.124(44B)
Figure 7-20.—Examples of properly made soldered joints.

1136

resulting from the forging process and to round off the sharp corners slightly. This is not always required when a tinned iron is to be retinned. Inspection will reveal if it is necessary. Then heat the copper tip hot enough so that it will readily melt solder. Try melting solder with the copper frequently as it is being heated, and as soon as it will melt solder, it is ready for tinning.

To tin the copper, first quickly dip it into rosin or apply rosin core solder to the tip of the iron. The coating of solder is bright and shiny and very thin. It aids in the rapid transfer of heat from the iron to the work.

SOLDERING PROCEDURE

Many equipment failures can be attributed to poorly soldered joints. Since such equipments aboard ship are subjected to continual vibration and frequent shock, it is imperative that all soldering be done with the utmost care. The following suggestions are presented in an effort to assist in effecting a good job of soldering.

The parts to be soldered must be absolutely clean (free from oxide, corrosion and grease). During the cleaning process, when removing insulation from wire, care must be taken to avoid producing cuts or nicks which greatly reduce the mechanical strength of the wire, especially under conditions of vibration.

The joint should be prepared just prior to soldering since the prepared surfaces will soon corrode or become dirty if it remains exposed to the air.

The parts to be joined must be securely joined mechanically before any soldering is done.

To solder electrical connections (fig. 7-19), hold the soldering iron (copper) beneath the splice being soldered with as much mechanical contact as possible to permit maximum heat transfer. Apply the rosin core solder to the splice. The tinning on the soldering iron aids the transfer of heat to the spliced wire which, when hot enough, will melt the solder. Before this temperature is reached the rosin core will have melted and run out over the wire to flux the splice. When the solder has coated the splice completely, the job is finished. No extra solder is needed.

A good, well-bonded connection is clean, shiny, smooth and round. It also approximately outlines the wire and terminal as shown in figure 7-20.

PRECAUTIONS

One sizzling burn experience is usually enough to breed a healthy respect for hot objects. When using a soldering iron or gun always bear in mind the following:

Electric soldering irons must not remain connected longer than necessary and must be kept away from flammable material.

In order to avoid burns, always assume that a soldering iron is hot.

Never rest a heated iron anywhere but on a metal surface or rack provided for this purpose. Faulty action on your part could result in fire, extensive equipment damage, and serious injuries.

Never swing an iron to remove solder because the bits of solder that come off may cause serious skin or eye burns or ignite combustible materials in the work area.

When cleaning an iron, use a cleaning cloth or damp sponge, but DO NOT hold the cleaning cloth or damp sponge in your hand. Always place the cloth or damp sponge on a suitable surface and wipe the iron across it to prevent burning your hand.

Hold small soldering jobs with your pliers or a suitable clamping device. Never hold the work in your hand.

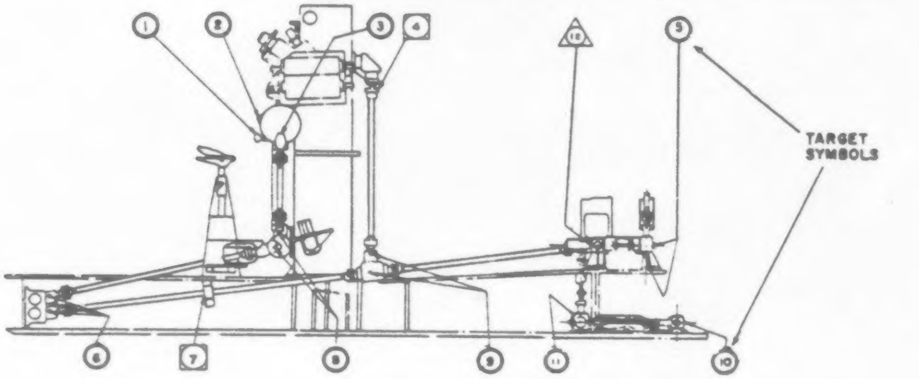
After completing the task requiring the use of a soldering iron, disconnect the power cord from the receptacle and, when the iron has cooled off, stow it in its assigned storage area. Do not throw irons into a toolbox. When storing irons for long periods of time, coat the shaft and all metal parts with rust-preventive compound and store in a dry place.

LUBRICATION

If you grew up in a large city, perhaps the only connection you had with lubrication was taking the family car to the garage or gasoline station for greasing and an oil change. If you grew up on a farm or had a car that you kept in running condition yourself, you are well aware of the need for regular lubrication of all moving parts. If your car ever burned out a bearing, you've had a lesson you are not likely to forget.

FUNCTIONS OF LUBRICANTS

Lubricants are used as coolants, to reduce friction, to prevent wear, and to protect against corrosion.



AT ASSEMBLY

4 RESPONSE GEAR ADJUSTING COUPLING
(COAT WORM TEETH)

WEEKLY OR 30 HOURS OPERATION (MINIMUM)

1 SHIFTING LEVER

2 HANDWHEEL HOUSING
(CHECK LEVEL AND REPLENISH)

3 HANDWHEEL HANDLES

5 INBOARD HOUSING ASSEMBLY
(1 FILL PLUG, 1 DRAIN PLUG)

6 TRAIN ORDER AND RESPONSE HOUSING
(3 FITTINGS, 1 LEVEL PLUG)

8 TRAIN ORDER GEAR HOUSING
(1 FITTING, 3 LEVEL PLUGS)

9 INTERMEDIATE RESPONSE GEAR HOUSING
(1 FITTING, 1 LEVEL PLUG)

10 TRAIN INPUT FRONT HOUSING
(FILL THRU COVER, 1 LEVEL PLUG)

11 TRAIN INPUT REAR HOUSING
(FILL THRU COVER, 1 LEVEL PLUG)

12 WORM AND WORMWHEEL HOUSING
(2 FILL PLUGS, 2 DRAIN PLUGS)

MONTHLY OR 120 HOURS OPERATION (MINIMUM)

7 PILLOW BLOCK ASSEMBLY

GENERAL LUBRICATION INSTRUCTIONS - REFER TO O.D. 3000

APPLICATION - EXERCISE PARTS WHILE LUBRICATING

REPORTS. - SHIPS EXPERIENCING ANY DIFFICULTY WITH OPERATION OF THE EQUIPMENT DUE TO LUBRICATION IN ACCORDANCE WITH THIS CHART SHOULD SUBMIT A DETAILED REPORT TO THE BUREAU OF ORDNANCE WITH COPY TO THE NAVAL GUN FACTORY.

CHECK-OFF LISTS. - REDUCED SIZE PHOTOPRINT COPIES OF THESE CHARTS MAY BE OBTAINED FROM THE NAVAL GUN FACTORY FOR USE AS PERIODIC CHECK-OFF LISTS.

REFERENCE CHARTS. -
FOR LUBRICATION OF PLAN ABOVE AND PLAN BELOW SHELF PLATE SEE DR. NO. 509299.
FOR LUBRICATION OF RIGHT SIDE ABOVE SHELF PLATE SEE DR. NO. 509301.

SYMBOL SPECIFICATIONS

△ INDICATES WORM GEAR LUBRICANT (O.S. 1400)

○ INDICATES LIGHT MINERAL OIL (NAVY SYMBOL 3050 OR 2135)*

▢ INDICATES BEARING GREASE (14-G10 (ORD))

*LUBRICANTS ARE SHOWN IN ORDER OF PREFERENCE

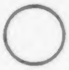
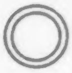
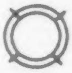
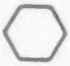
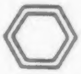
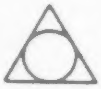
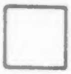
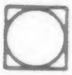
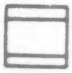
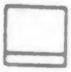
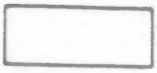
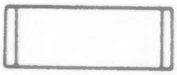
6IN. TRAINING GEAR MK.3 MOD.1
(47 CAL. DOUBLE PURPOSE TWIN)
LEFT SIDE ABOVE SHELF PLATE
(LOOKING OUTBOARD)
LUBRICATION CHART
509300

Figure 7-21.—Lubrication chart showing lubricating symbols, schedules of lubrication, and other instructions.

84.278

Table 7-2.—Targets and Corresponding Lubricants Appearing on Lubrication Charts

44.221

TARGET SYMBOL	NAME OF LUBRICANT	SPECIFICATION
	Lubricating Oil, General Purpose	MIL-L-15016 (MS 3042) (Supersedes NS 3042)
	Lubricating Oil, General Purpose	MIL-L-15016 (MS 3050) (Supersedes NS 3050)
	Lubricating Oil, Aircraft Reciprocating (Piston) Engine	MIL-O-6082 (Grade 1065) (Supersedes NS 1065)
	Lubricating Oil, Preservative, Light	MIL-L-3503 (Supersedes 14L17 (Ord))
	Lubricating Oil, Aircraft Instrument, Low Volatility	MIL-L-6085 (Supersedes 14-0-20 (Ord))
	Lubricant, Worm Gear	MIL-L-18486 (NOrd) (Supersedes OS 1400)
	Grease, Extreme Pressure	MIL-G-17740 (NAVY) (Supersedes 14G9 (Ord))
	Grease, Bearing, for General Ordnance Use	MIL-G-16908 (BuOrd) (Supersedes 14G10)
	Grease, Instrument	MIL-G-15793 (BuOrd) (Supersedes 14G8 (Ord))
	Lubricant, Ball, and Roller Bearing	MIL-G-18709 (NAVY) (Supersedes 14L3)
	Lubricants, Fluids, Preservatives, etc., Other Than Those Indicated Above	As Specified
		Used To Designate Special Notes, References, and Instructions

In mechanical devices, lubrication is necessary to minimize friction between moving parts. Only the presence of a layer or film of lubricant between metal surfaces keeps the metals from touching. Moving parts "ride" on this film. As a result, friction is reduced between the moving parts.

Prolonged operating life is ensured when the thin film of lubricant keeps metal surfaces from direct contact with each other. If the film disappears, you have "hot-boxes," burned out and frozen bearings, scored cylinder walls, leaky packings and a host of other troubles. Appropriate use of proper lubricants minimizes possible damage to equipment.

LUBRICANTS

Lubricants are of two general classes—oils and greases. Oils are fluids; greases are semisolid at ordinary temperatures. For many applications, liquid lubricants are more suitable than greases, particularly if the lubricant can be retained, as in an oil bath, a gear box, or in a forced-feed system. Where conditions are such that oil is not readily retained, or additional protection against corrosion is needed, greases are used.

CHARTS AND INSTRUCTIONS

How do you know which oil or grease to select for a particular application? Lubrication charts and instructions will provide this information.

Lubrication instructions are issued for all naval equipment requiring lubrication. Such instructions may be issued as lubrication charts, maintenance requirement cards, notices, or any combination of these.

Lubrication charts (fig. 7-21) generally indicate the approved lubricants, lubrication points, frequency of lubrication, and the target symbol (table 7-2) of the lubricant.

GREASE GUNS

The types of grease guns shown in figure 7-22 operate on the same principle, but differ in the ways they are loaded. You load one type by removing a cap that comes off with the handle and stem, and filling the body with grease, using a paddle or spatula. As you might expect, this method of loading can be messy, and it also exposes the lubricant to dirt and moisture.

In a second type, you load by inserting a prepacked cartridge of grease into the body of the gun. This loading method is fast and clean. The gun shown in figure 7-22A also loads fast and clean. You load it by removing the cap nut from the end of the hollow handle and forcing grease in through the handle with a hand gun loader (fig. 7-23A), or a bucket-type lubricant pump (fig. 7-23B).

The hand gun loader is a 25-pound container equipped with a hand-operated pump and a fitting that mates with the opening in the handle of the grease gun. The bucket-type lubricant pump makes use of a loader adapter and loader valve when it is used for loading a grease gun. One pound of lubricant is delivered with every seven full strokes of the pump. The loader will deliver lubricant only when the gun is placed on the loader valve. You can see how much less messy the loader is than the paddle, and how it protects the lubricant against contamination. Besides, you don't have to run back to the storeroom to refill your gun.

Different nozzles can be attached to the grease guns for different types of fittings. The lubricant pump also has various couplers and adapters that attach to the hose, so that the pump can be used on different fittings.

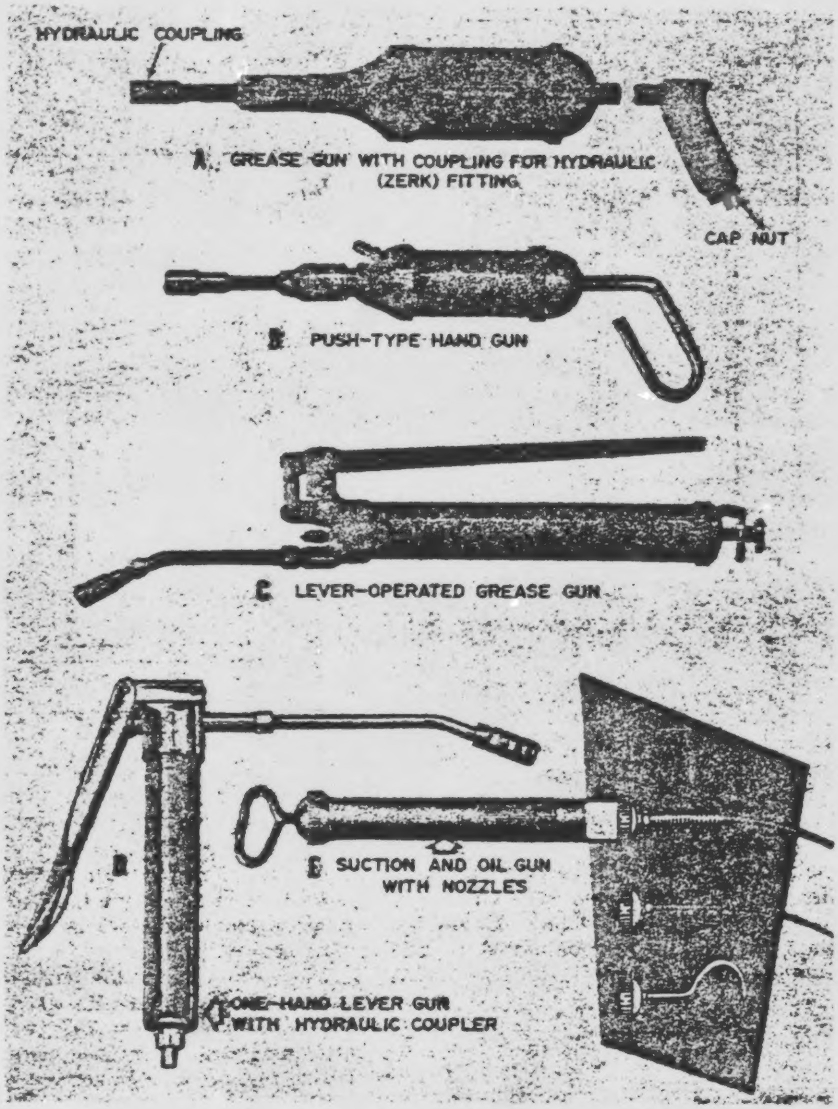
Grease guns can be used for oil if the point to be lubricated has the proper fitting, or an oil gun (fig. 7-22E) may be used.

FITTINGS

Grease fittings are of several types—hydraulic (unofficially called the Zerk fitting), buttonhead, pin-type, and flush (fig. 7-24).

The hydraulic fitting protrudes from the surface into which it is screwed, and has a specially shaped rounded end that the mating nozzles of the grease guns can grip. A spring-loaded ball acts as a check valve. The nozzle will not slip off the fitting during lubrication, but can be easily disengaged by a quick forward-backward movement. Figure 7-24A shows a cross section view of a straight hydraulic fitting and figure 7-24C shows angled hydraulic fittings made for lubrication points that are hard to reach.

The flush fitting (fig. 7-24B) is flush with (or below) the surface into which it is set, so that it will not interfere with moving parts. It is also used where there is not sufficient clearance to install protruding fittings.


HYDRAULIC COUPLING
A. GREASE GUN WITH COUPLING FOR HYDRAULIC (ZERK) FITTING
CAP NUT
B. PUSH-TYPE HAND GUN
C. LEVER-OPERATED GREASE GUN
D
E. SUCTION AND OIL GUN WITH NOZZLES
ONE-HAND LEVER GUN WITH HYDRAULIC COUPLER

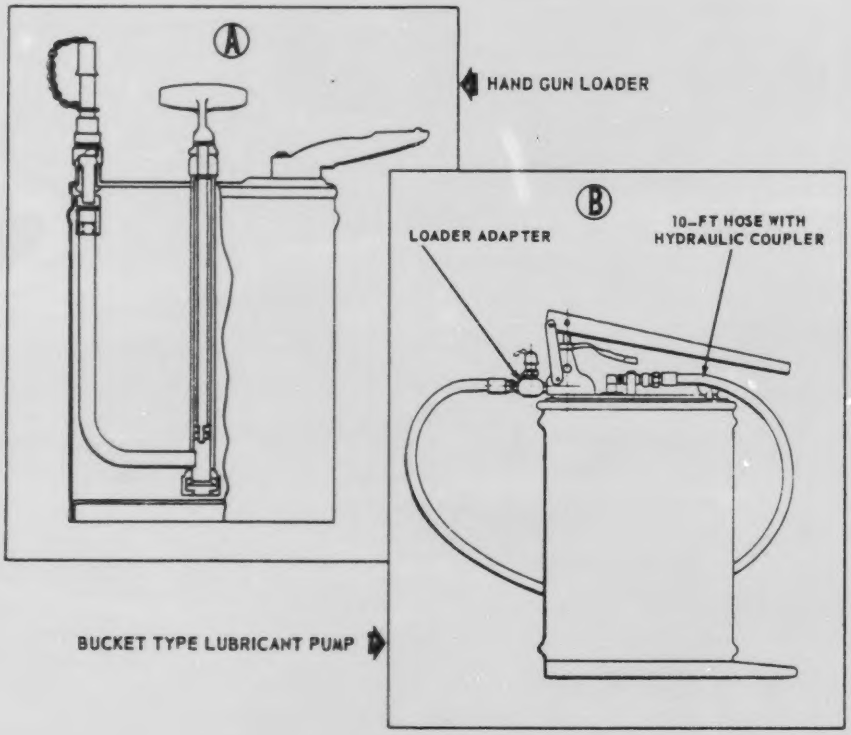
83.120

Figure 7-22.—Hand-operated grease guns.

Button-head and pin-type fittings (figs. 7-24D and E) provide a more positive connection with the grease gun. A simple quarter turn of the grease gun on the pin-type fitting locks the connection between the gun and the fitting.

The oil cup with ball valve (fig. 7-24F) is the most popular for oil fittings.

Plastic protective caps often are provided for use on hydraulic fittings to prevent the entrance of dirt and water, and to protect the



83.121

Figure 7-23.—Hand-operated grease pumps.

fittings during ice removal, painting and similar operations. The caps also prevent the greases from hardening in the fitting. If available, use them after you have completed your lubrication task.

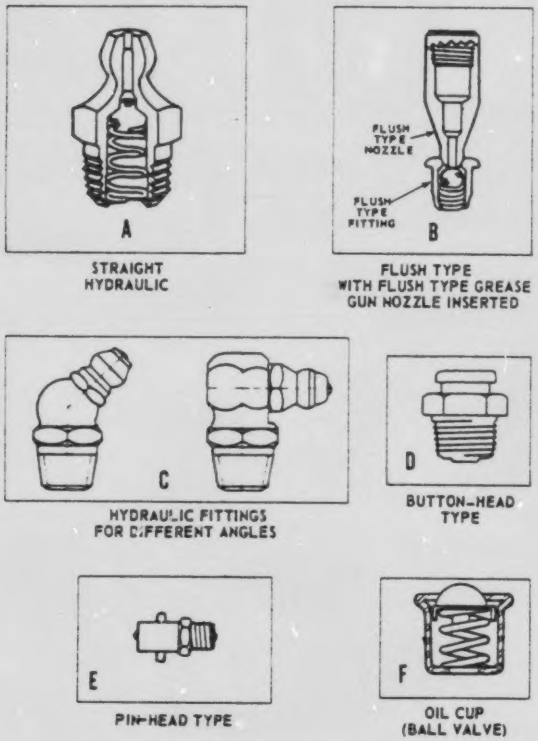
USING A HAND-OPERATED GREASE GUN

To use a push-type, hand-operated grease gun, you connect the nozzle of the gun to its corresponding fitting at the lubrication point and work the handle in and out. To connect the gun, align the nozzle and the fitting end-to-end and push on the gun handle so the nozzle slips over the hydraulic fitting or into the flush fitting. At the same time that the nozzle mates with the fitting, the handle moves inward to build pressure inside the gun to force grease out of the nozzle and into the fitting. Then, let up on the handle a moment. A spring in the gun will then force the handle out a little way and prepare the gun for another inward stroke of the handle.

When you connect the push-type gun to a hydraulic fitting, the nozzle grips the fitting and is held firmly only as long as the nozzle and fitting are aligned or until pulled free. In connecting the gun to a flush type fitting, however, you must keep a steady pressure on the fitting because the nozzle doesn't grip the fitting (fig. 7-24B).

LUBRICATING PROCEDURE

As with other routine jobs, it helps to have a standard operating procedure that you can habitually follow. Here's one that will be helpful when lubricating.



STRAIGHT HYDRAULIC

FLUSH TYPE WITH FLUSH TYPE GREASE GUN NOZZLE INSERTED

HYDRAULIC FITTINGS FOR DIFFERENT ANGLES

BUTTON-HEAD TYPE

PIN-HEAD TYPE

OIL CUP (BALL VALVE)

Figure 7-24.—Lubrication fittings.

83.122

1. First, consult the lubrication chart to learn the location of each fitting.

2. After locating a fitting, clean it with a lintless cloth.

3. Apply the correct amount of the specified lubricant. (Be careful of the amount you apply—too much will cause excessive heat in the bearing and strain the grease retainers, while too little is on a par with too late.)

4. Wipe all excess grease from around the fitting.

5. Check off the fitting on your chart. A fitting must not be missed just because it is battered or frozen. A battered fitting must be replaced. A "frozen" fitting probably means that the oil holes throughout the bearing are clogged. This means tearing down the bearing and cleaning all parts carefully. Grease that fitting even if it requires an hour of extra work!

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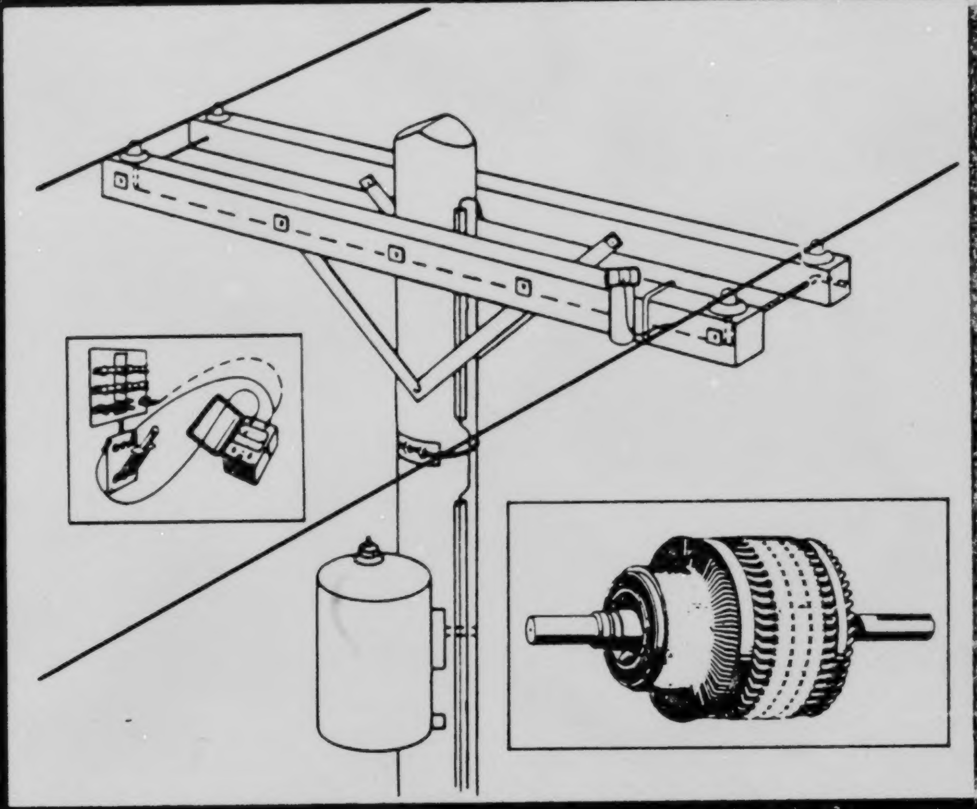


CONSTRUCTION ELECTRICIAN 3 & 2

BUREAU OF NAVAL PERSONNEL

RATE TRAINING MANUAL NAVPERS 10636-G

Only Chapters 2, 4, 7, 8, and 9 of this publication have been included with this course. These are the chapters required as readings for the course.

CHAPTER 2

BLUEPRINTS, DIAGRAMS AND SCHEMATICS

This chapter discusses the uses and importance of being able to read and interpret elementary and detailed wiring diagrams and schematics. These diagrams and schematics are maps which indicate the location of circuits and circuit connections of electrical installations and equipment.

Blueprints are reproductions of these working drawings. When properly utilized, they are an invaluable aid in troubleshooting or in determining faults in an electrical circuit. Locating and repairing faults are undoubtedly the most important work assignments you will have.

You will also be required to install new circuits or repair old construction. The proper use of blueprints pays dividends in many ways. For example, blueprints will save many manhours of "sight-traveling" cables as you seek malfunctions or an unknown termination point.

The ships, planes, buildings, and guns of the Navy were built from plans on blueprints and they are operated, checked, and maintained according to information found on these blueprints. When mechanisms fail in service or are damaged in battle, blueprints are used to aid the repairman. When new parts are to be made or the system is expanded, blueprints provide the necessary information. Remember, too, that much planning and manpower and material estimating is based on the information contained in these blueprints.

BLUEPRINT READING

The term "blueprint reading" refers to the ability to express the meanings conveyed in drawings, whether the drawings are actually blueprints or not. Be aware that all blueprints are not blue in color, but a drawing of any color which delineates a master or key plan. A very important reference book is the basic Navy training manual Blueprint Reading and Sketching, NavPers 10077-C. Chapters 1 through 5 are especially pertinent to the Construction Electrician. Be sure to review the contents of these chapters in the latest edition of this manual.

HANDLE WITH CARE

Blueprints are valuable permanent records which can be used again and again if you take care of them. Here are some simple rules for obtaining the best results from them.

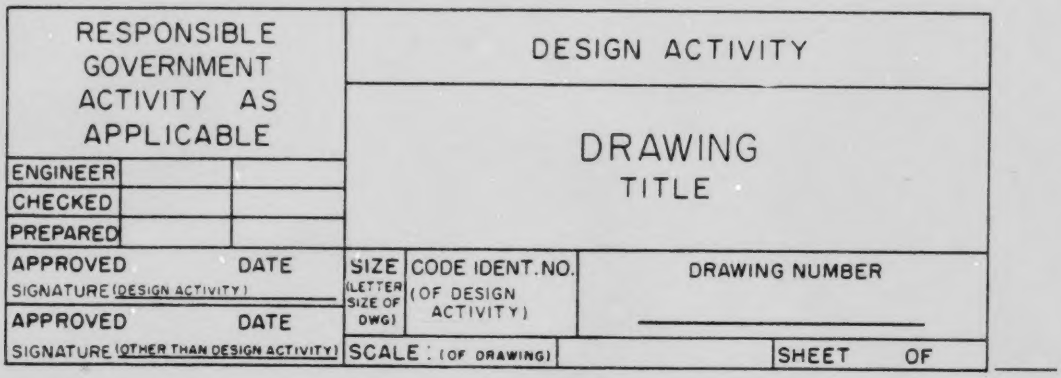
- Keep them out of sunlight to prevent fading.
- DO NOT make pencil or crayon notations on a print without proper authority. If you should be instructed to mark a blueprint, use a pencil with appropriately colored lead. A yellow crayon provides good contrast to a blue background since ordinary black-lead pencil marks are hard to see on a colored background.
- Avoid getting the prints wet or grease-smudged.
- Keep prints stored properly so they can be located quickly the next time you need them.

FOLDING BLUEPRINTS

A standardized, accurate system of filing blueprints is necessary so that prints may be found quickly. This standardized system ensures that the identifying marks appear in the same place, preferably at the top, when the prints are in vertical filing order. Most of the prints you will see will already be properly folded. Your only concern will be to see that they are refolded correctly. If you use prints that have not been folded at all, or that have been folded improperly, fold them in such a manner that the drawing number in the lower right hand corner of the title block appears on the outside. (Some older drawings may have the drawing numbers placed in other portions of the title block.)

PARTS OF A BLUEPRINT

The chief part of a drawing is, of course, the graphic representation of the object, whatever it may be, together with dimension lines, dimensions, symbols, and other graphic devices which explain the representation. Additional information is inscribed in the title block, the bill of materials, the scale, and the legends, and notes.


RESPONSIBLE GOVERNMENT ACTIVITY AS APPLICABLE
DESIGN ACTIVITY
DRAWING
TITLE
ENGINEER
CHECKED
PREPARED
APPROVED DATE
SIGNATURE (DESIGN ACTIVITY)
APPROVED DATE
SIGNATURE (OTHER THAN DESIGN ACTIVITY)
SIZE (LETTER SIZE OF DWG)
CODE IDENT. NO. (OF DESIGN ACTIVITY)
DRAWING NUMBER
SCALE : (OF DRAWING)
SHEET OF

45.159(73G)

Figure 2-1.—Title block.

Title Block

The title block (fig. 2-1) gives the title of the drawing, and the number that has been assigned to that drawing. It indicates also who prepared the drawing, who checked it, the authority under which it was issued, and the date approved.

Drawing Number

The drawing number is especially important, both for purposes of filing the blueprint, and for locating the correct drawing when it is specified on another blueprint. For example, where a number of separate buildings shown on a series of blueprints are to have identical wiring systems, cross-referencing the other drawings to one plan which shows all the details saves the labor of repeating the wiring system on every drawing.

Bill of Material

The bill of material is a list of all the items required to install a particular piece of equipment or to erect a particular building. The list includes stock number, description, and quantity of each item. As you can see by referring to figure 2-2, the list is complete down to the last screw.

When equipment assemblies are received at an advanced base, it is possible for you, by checking the bill of material, to quickly determine if the items shipped are what you need for the job in hand, and whether or not they allow for changes made necessary by local conditions.

Scale

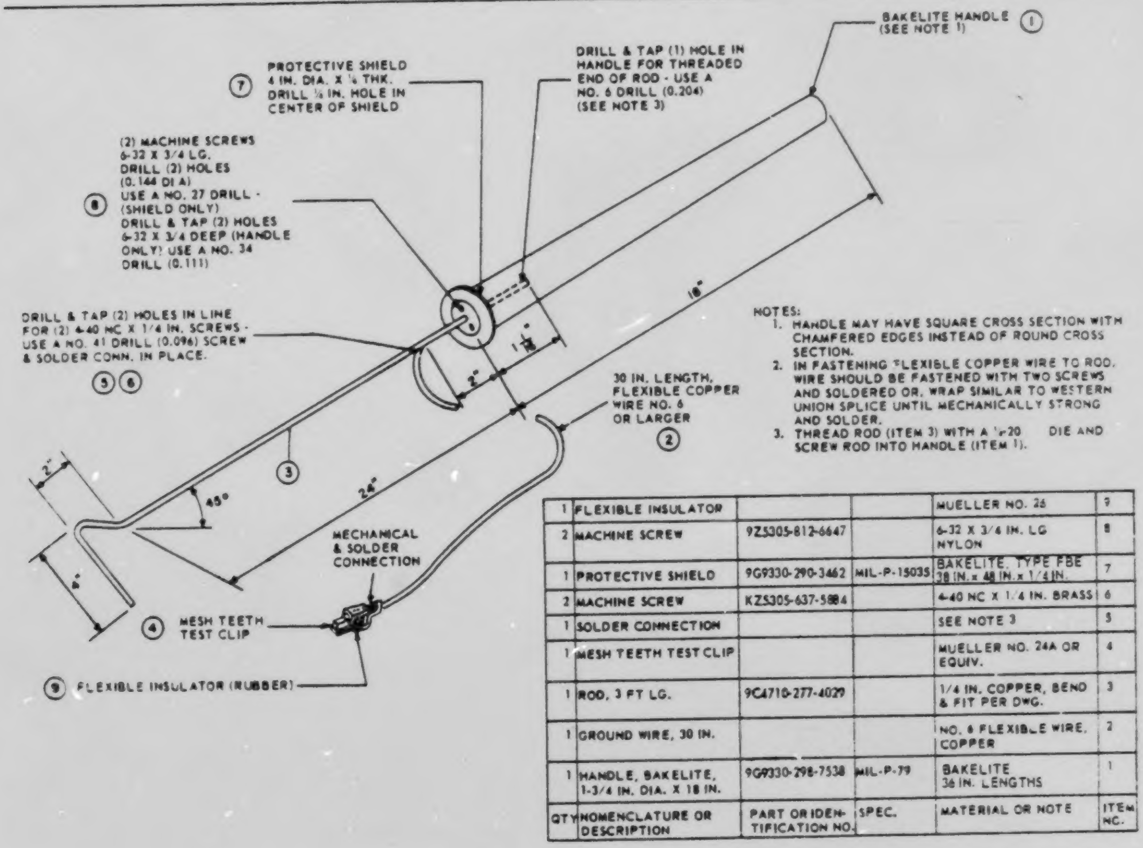
The scale of a drawing is particularly important to the Builders, but it has a practical value to the Construction Electrician as well. Dimensions of buildings, and distances between them, will have to be considered in figuring the number of reels of wire required, and the number of poles to be erected, or the amount of wire and conduit in the building.

Avoid measuring distance on a blueprint. Why? One reason is that the drawing may have been reduced in size from the original. Another is that the print may have shrunk or stretched. Whenever possible, you should READ the dimensions indicated on the drawings in preference to scaling the distance.

If scaling is unavoidable, the graphic scale must be checked for possible expansion or shrinkage. Be sure to avoid using a wrong scale. Note especially if any details are drawn to a scale different than that of the rest of the drawing. Play it safe and READ dimensions; they always remain the same.

Notes and Legends

The notes and legends which you can expect to appear on a drawing are illustrated in figure 2-3. These notes contain equipment specifications, procedures for installing, and operating


BAKELITE HANDLE (SEE NOTE 1) ①
DRILL & TAP (1) HOLE IN HANDLE FOR THREADED END OF ROD - USE A NO. 6 DRILL (0.204) (SEE NOTE 3)
⑦ PROTECTIVE SHIELD 4 IN. DIA. X ¼ THK. DRILL ¼ IN. HOLE IN CENTER OF SHIELD
⑧ (2) MACHINE SCREWS 6-32 X 3/4 LG. DRILL (2) HOLES (0.144 DIA) USE A NO. 27 DRILL - (SHIELD ONLY) DRILL & TAP (2) HOLES 6-32 X 3/4 DEEP (HANDLE ONLY) USE A NO. 34 DRILL (0.111)
DRILL & TAP (2) HOLES IN LINE FOR (2) 4-40 NC X 1/4 IN. SCREWS - USE A NO. 41 DRILL (0.096) SCREW & SOLDER CONN. IN PLACE.
⑤⑥
18"
1 ½"
2"
30 IN. LENGTH, FLEXIBLE COPPER WIRE NO. 6 OR LARGER ②
③
2"
45°
24"
6"
MECHANICAL & SOLDER CONNECTION
④ MESH TEETH TEST CLIP
⑨ FLEXIBLE INSULATOR (RUBBER)

NOTES:
1. HANDLE MAY HAVE SQUARE CROSS SECTION WITH CHAMFERED EDGES INSTEAD OF ROUND CROSS SECTION.
2. IN FASTENING FLEXIBLE COPPER WIRE TO ROD, WIRE SHOULD BE FASTENED WITH TWO SCREWS AND SOLDERED OR, WRAP SIMILAR TO WESTERN UNION SPLICE UNTIL MECHANICALLY STRONG AND SOLDER.
3. THREAD ROD (ITEM 3) WITH A ¼-20 DIE AND SCREW ROD INTO HANDLE (ITEM 1).

QTY	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFICATION NO.	SPEC.	MATERIAL OR NOTE	ITEM NO.
1	FLEXIBLE INSULATOR			MUELLER NO. 26	9
2	MACHINE SCREW	9Z5305-812-6647		6-32 X 3/4 IN. LG NYLON	8
1	PROTECTIVE SHIELD	9G9330-290-3462	MIL-P-15035	BAKELITE, TYPE FBE 38 IN. x 48 IN. x 1/4 IN.	7
2	MACHINE SCREW	KZ5305-637-5884		4-40 NC X 1/4 IN. BRASS	6
1	SOLDER CONNECTION			SEE NOTE 3	5
1	MESH TEETH TEST CLIP			MUELLER NO. 24A OR EQUIV.	4
1	ROD, 3 FT LG.	9C4710-277-4029		1/4 IN. COPPER, BEND & FIT PER DWG.	3
1	GROUND WIRE, 30 IN.			NO. 6 FLEXIBLE WIRE, COPPER	2
1	HANDLE, BAKELITE, 1-3/4 IN. DIA. X 18 IN.	9G9330-298-7538	MIL-P-79	BAKELITE 36 IN. LENGTHS	1

1.1(26D)

Figure 2-2.—Safety shorting probe.

instructions. They may also contain explanations of parts of the drawing, and other pertinent information not included in the views themselves.

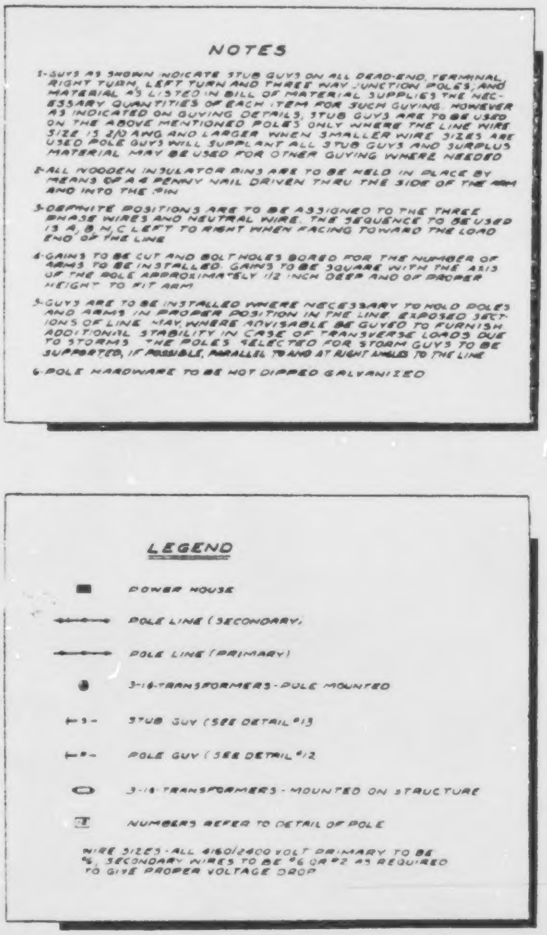
The legend lists the meaning of various symbols, abbreviations, and item numbers. This is a great help to the men of various ratings who may be engaged in the work, since not all of them would know the symbols well enough immediately to grasp the overall plan for the construction job. You will find legends a help when the drawings relate to a job where you must plan the laying of conduit and running of wire around plumbing fixtures, valves, duct work, or pipelines.

Electrical Symbols

The number of symbols and of abbreviations that may be used on drawings runs into the thousands. All draftsmen do not employ the same symbol to represent a particular item. These two facts can make blueprint reading a major task for any rating.

Fortunately, however, the Department of Defense prescribes MILITARY STANDARDS in this and other areas, which make for a high degree of uniformity in symbols employed in drawings used by the armed services. Graphic symbols for electrical diagrams are prescribed in American National Standard Institute, Standard # Y 32.2, dated 1967. Wiring symbols for electrical drawings are shown in MIL-STD-15-3, Part 3, Electrical Wiring Symbols for Architectural and Electrical Layout Drawings.

Other standards you should be familiar with are MIL-STD-12B, Abbreviations for Use on Drawings and MIL-STD-103, Abbreviations for Electrical and Electronics Use.



NOTES

1-GUYS AS SHOWN INDICATE STUB GUYS ON ALL DEAD-END, TERMINAL, RIGHT TURN, LEFT TURN AND THREE WAY JUNCTION POLES, AND MATERIAL AS LISTED IN BILL OF MATERIAL SUPPLIES THE NECESSARY QUANTITIES OF EACH ITEM FOR SUCH GUYING. HOWEVER AS INDICATED ON GUYING DETAILS, STUB GUYS ARE TO BE USED ON THE ABOVE MENTIONED POLES ONLY WHERE THE LINE WIRE SIZE IS 2/0 AWG AND LARGER. WHEN SMALLER WIRE SIZES ARE USED POLE GUYS WILL SUPPLANT ALL STUB GUYS AND SURPLUS MATERIAL MAY BE USED FOR OTHER GUYING WHERE NEEDED

2-ALL WOODEN INSULATOR PINS ARE TO BE HELD IN PLACE BY MEANS OF A 4 PENNY NAIL DRIVEN THRU THE SIDE OF THE ARM AND INTO THE PIN

3-DEFINITE POSITIONS ARE TO BE ASSIGNED TO THE THREE PHASE WIRES AND NEUTRAL WIRE. THE SEQUENCE TO BE USED IS A, B, N, C LEFT TO RIGHT WHEN FACING TOWARD THE LOAD END OF THE LINE

4-GAINS TO BE CUT AND BOLT HOLES BORED FOR THE NUMBER OF ARMS TO BE INSTALLED. GAINS TO BE SQUARE WITH THE AXIS OF THE POLE APPROXIMATELY 1/2 INCH DEEP AND OF PROPER HEIGHT TO FIT ARM

5-GUYS ARE TO BE INSTALLED WHERE NECESSARY TO HOLD POLES AND ARMS IN PROPER POSITION IN THE LINE. EXPOSED SECTIONS OF LINE MAY, WHERE ADVISABLE, BE GUYED TO FURNISH ADDITIONAL STABILITY IN CASE OF TRANSVERSE LOADS DUE TO STORMS. THE POLES SELECTED FOR STORM GUYS TO BE SUPPORTED, IF POSSIBLE, PARALLEL TO AND AT RIGHT ANGLES TO THE LINE

6-POLE HARDWARE TO BE HOT DIPPED GALVANIZED

LEGEND

POWER HOUSE

POLE LINE (SECONDARY)

POLE LINE (PRIMARY)

3-1Φ-TRANSFORMERS-POLE MOUNTED

STUB GUY (SEE DETAIL #13

POLE GUY (SEE DETAIL #12

3-1Φ-TRANSFORMERS-MOUNTED ON STRUCTURE

NUMBERS REFER TO DETAIL OF POLE

WIRE SIZES-ALL 4160/2400 VOLT PRIMARY TO BE #6, SECONDARY WIRES TO BE #6 OR #2 AS REQUIRED TO GIVE PROPER VOLTAGE DROP

73.2

Figure 2-3.—Representative notes and legends.

MIL-STD-12B contains a list of those abbreviations customarily used on all construction drawings. MIL-STD-103 supplements this by dealing specifically with abbreviations used only on electrical and electronic drawings.

All of the references listed should be available in your battalion. However, you should memorize the symbols shown in MIL-STD-15-3, Part 3, Electrical Wiring Symbols for Architectural and Electrical Layout Drawings.

Use every opportunity you have to study the blueprints of the job to which you are assigned. Try to picture in your mind the item represented by each symbol. Trace the electrical circuits estimating the length of wire required for each circuit, and the locations of conductors and parts. When the lines, symbols, abbreviations, and notes make an understandable mental picture to you, you have learned to read an electrical drawing. Remember . . . if you do not understand what portions of the diagram mean, ask your senior.

ACCURACY

Your chief may ask you to determine the amount of Romex cable to be used for wiring a building. He'll hand you a blueprint . . . and if it doesn't have any BILL OF MATERIAL, you'll have to obtain the information from appropriate measurements.

Be sure you don't overlook any of the circuits. One way to be sure is to cross out, with colored crayon, each circuit as soon as you have completed its measurement.

DIAGRAMS AND SCHEMATICS

Construction electricians, who know the trade, "talk with diagrams." When a technical question is brought up, a single diagram is often worth more than hours of discussion.

There are a number of types of electrical drawings. These may vary from wiring diagrams (scale drawings of electrical apparatus which show the exact location of all wiring and connections), to schematic diagrams and architectural plans.

In figure 2-4, a pictorial drawing, an elementary wiring diagram, and a schematic are compared. They show exactly the same thing, but they look quite different.

Let's see how diagrams prove their worth in voltage distribution, interior wiring, communications, and planning. Your work may involve you in any or all of these areas.

EXTERNAL DISTRIBUTION SYSTEMS

Figures 2-5 and 2-6 illustrate a pictorial and schematic view of a three-wire distribution system. Assume that the system has a delta-connected alternator generating 220 volts. From the generating station, three-wire feeders carry the power overhead to the distribution center, from which two primary mains branch off. One of these carries power to a lighting system and

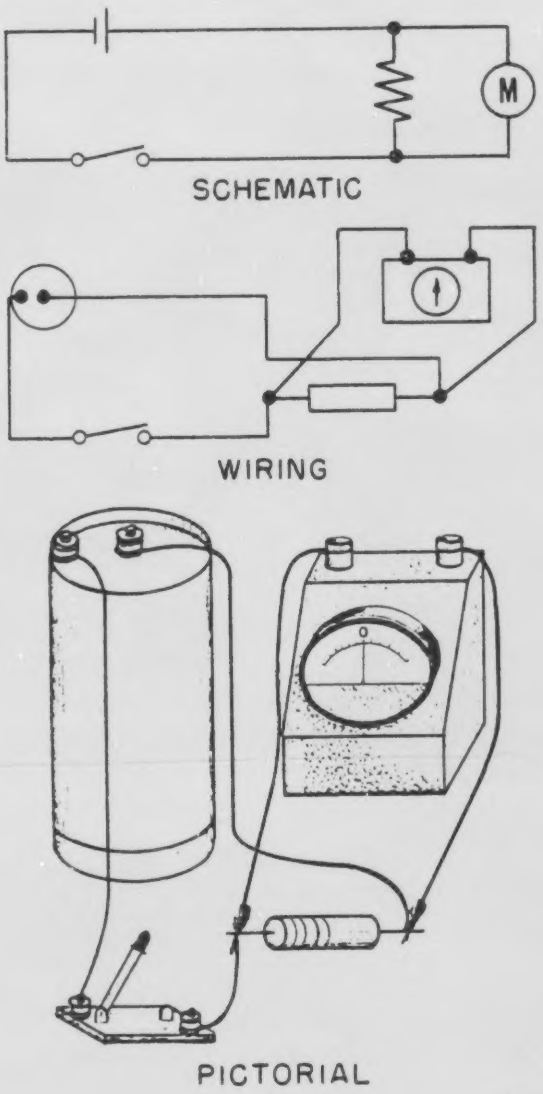


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Figure 2-4.—Variety of diagrams.

single-phase motor in a motor pool, both designed to operate on 110 volts, and to a three-phase motor designed to operate on 220 volts. The 220-volt three-phase motor is connected directly to the 220-volt three-phase primary main. For the lighting system and 110-volt motor, however, two wires in the primary main are tapped off to a transformer which reduces the 220-volt primary main voltage to 110 volts. Similarly, power to secondary mains running to operational headquarters, living headquarters, and mess hall is reduced to 110 volts.

A PLAN drawing is another type of drawing useful in exterior layout. Figure 2-7A and 2-7C shows views from directly above the items in the drawing and the proportion and relations of parts or objects to one another. The PLOT PLAN (fig. 2-7A) shows an area and gives the exact layout of various buildings, roads, equipment, etc.

Figure 2-7A is a plot plan showing 5 buildings which are to be supplied with electricity for power and lighting. An electrical layout has been superimposed. General notes (fig. 2-7B), one detail (fig. 2-7C) and section A-A (fig. 2-7D) of that detail are shown. The dotted line at the bottom of the drawing indicates underground ducts containing previously laid cable.

The design engineer has decided to tap the cable at manhole (M.H.) 22, and run lines from there overhead to dead end at the rear of building 126. Figure 2-7C shows that lines are to be run underground from M.H. 22 to the first pole, up the pole to conductors on the pole crossarms. At building 126, lines are to be carried down the pole, regathered through a pothead into conduit again, and run underground to a concrete slab, and out through another pothead to a transformer bank. Where do you get this information? Refer to figure 2-8.

Figure 2-8 shows the detail B indicated in figure 2-7A. This represents the installation behind building 126, where the overhead line terminates. The last pole in the system is shown in the lower left corner. From the pole to the transformer bank, the underground conduit is indicated by dotted lines. The conduit runs underground to the concrete slab on which the transformers rest. Section A-A gives construction details of this slab.

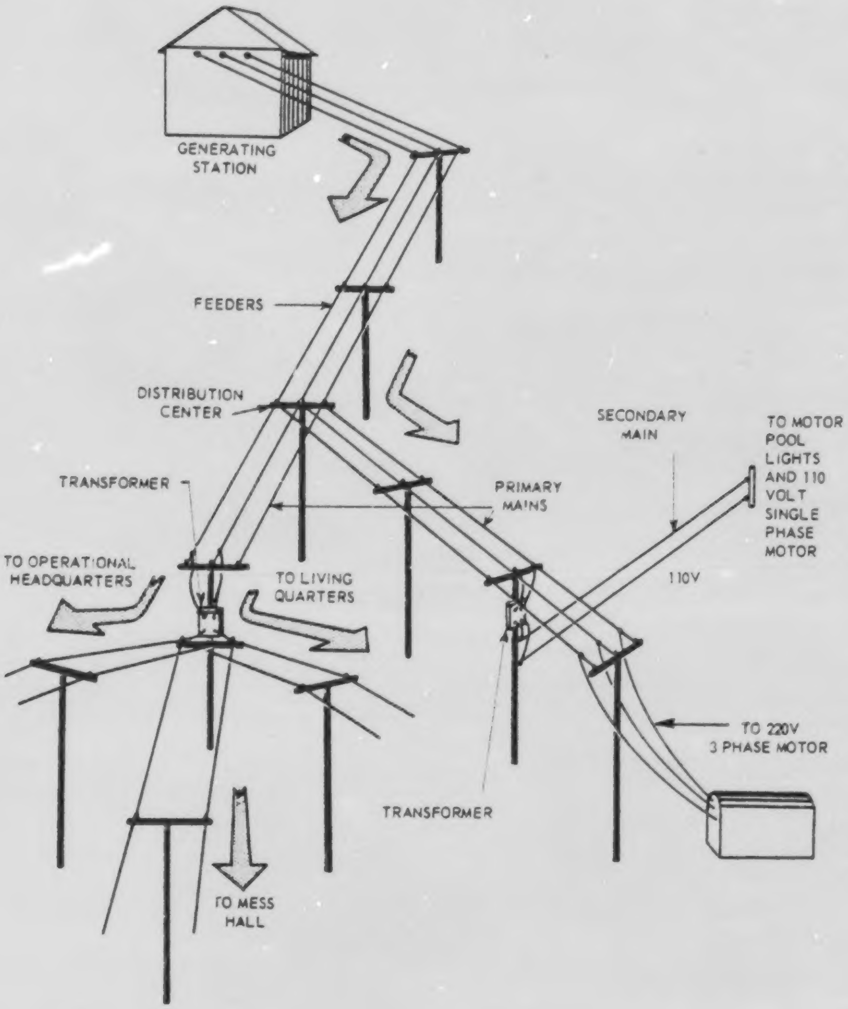
The angle-iron sumbols in figure 2-8, with the dimensions 3" x 3", indicate that the BUS (connecting conductor) running along the transformer primaries will be supported on posts made of 3" x 3" angles. From the transformer secondaries, underground conduits (indicated by dotted lines) will run to the junction box on building 126.

Pay attention to the various notes and details indicated in drawings. Your life, and the lives of your shipmates and equipment may depend on the care you take when reading and interpreting drawings.

INTERIOR WIRING

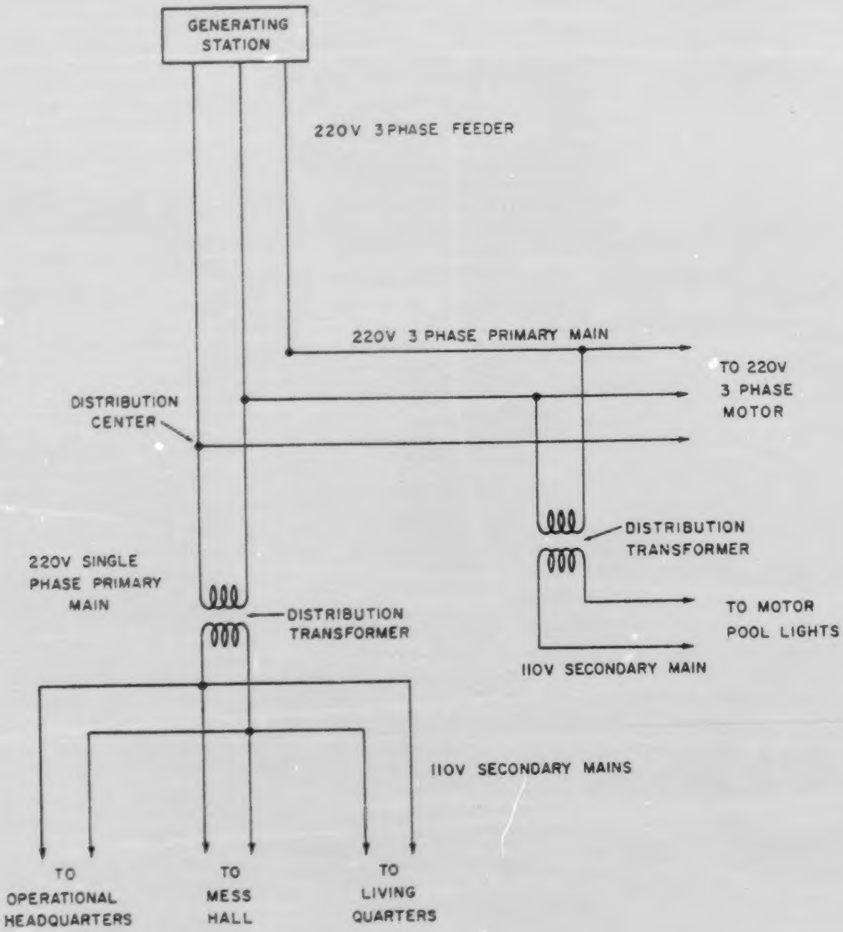
Figure 2-9 shows an electrical layout superimposed on an outline taken from an architectural floor plan. The service line bringing power into the house is a 3-wire line in 1 1/4-in. conduit. However, the fact that the line voltage is 120/240 indicates that these three wires must be two hot wires and a neutral wire from a 4-wire system. The third hot wire is not brought into the house.

The service line runs by way of a service switch to a lighting panel, from which three BRANCH CIRCUITS run to the lighting fixtures and convenience outlets in the rooms. The character of these fixtures and outlets, and of


GENERATING STATION
FEEDERS
DISTRIBUTION CENTER
SECONDARY MAIN
TO MOTOR POOL LIGHTS AND 110 VOLT SINGLE PHASE MOTOR
TRANSFORMER
PRIMARY MAINS
110V
TO OPERATIONAL HEADQUARTERS
TO LIVING QUARTERS
TO 220V 3 PHASE MOTOR
TRANSFORMER
TO MESS HALL

82.71

Figure 2-5.—Three-wire distribution system, pictorial view.


GENERATING STATION
220V 3PHASE FEEDER
220V 3 PHASE PRIMARY MAIN
TO 220V 3 PHASE MOTOR
DISTRIBUTION CENTER
DISTRIBUTION TRANSFORMER
220V SINGLE PHASE PRIMARY MAIN
DISTRIBUTION TRANSFORMER
TO MOTOR POOL LIGHTS
110V SECONDARY MAIN
110V SECONDARY MAINS
TO OPERATIONAL HEADQUARTERS
TO MESS HALL
TO LIVING QUARTERS

82.72

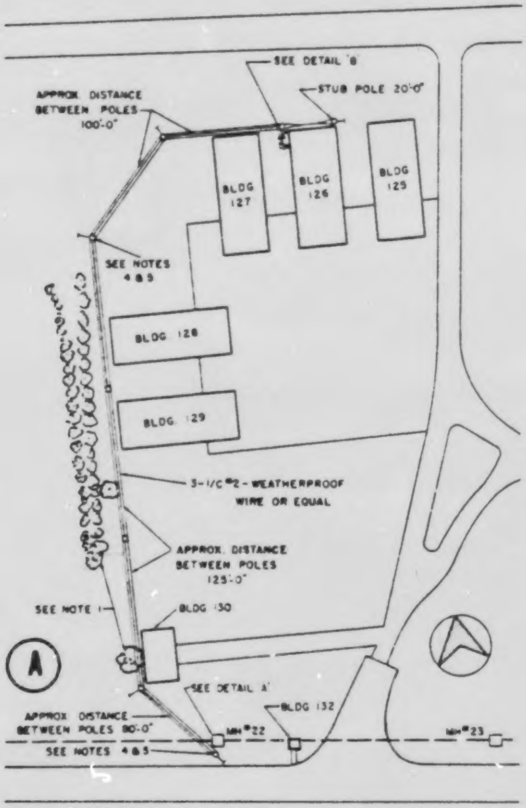
Figure 2-6.—Three-wire distribution system schematic.

the service switch and the lighting panel, is shown under "symbols."

Figure 2-10 is a wiring diagram showing the connections for the layout shown in figure 2-9. After entering the building, the two hot wires (black) in the service lead are connected to and fused at the service switch, while the neutral wire bypasses the switch and runs to the NEUTRAL BAR in the panel board, with a branch off to a waterpipe ground. Beyond the service switch, the two hot wires run to vertical LIVE BARS in the panel board.

The panel board is equipped to handle 6 circuits, with only three shown in the diagram. Consider branch circuit 4. This contains two wires, a hot wire running out from the live bar in the panel board, and a neutral (white) wire running back to the neutral bar in the panel board. This circuit contains only a single switch, which turns all the lights in the circuit on or off simultaneously, but has no effect on the flow of power to the convenience outlets.

Circuit #2 similarly contains a hot wire out from the panelboard and a neutral wire back.


SEE DETAIL 'B'
STUB POLE 20'-0"
APPROX. DISTANCE BETWEEN POLES 100'-0"
BLDG 127
BLDG 126
BLDG 125
SEE NOTES 4 & 5
BLDG 128
BLDG 129
3-1/C #2 - WEATHERPROOF WIRE OR EQUAL
APPROX. DISTANCE BETWEEN POLES 125'-0"
SEE NOTE 1
BLDG 130
A
SEE DETAIL 'A'
BLDG 132
APPROX. DISTANCE BETWEEN POLES 80'-0"
MH #22
MH #23
SEE NOTES 4 & 5

GENERAL NOTES -

1 - TREES OBSTRUCTING POLE LINE TO BE TRIMMED OR REMOVED AS DIRECTED BY CONSTRUCTION OFFICER

2 - PROVIDE LIGHTNING ARRESTERS, AT EACH END OF POLE LINE, ON ALL THREE OVERHEAD WIRES. GROUND LIGHTNING ARRESTERS WITH SUITABLE BARE WIRE CONNECTED TO DRIVEN GROUND ROD

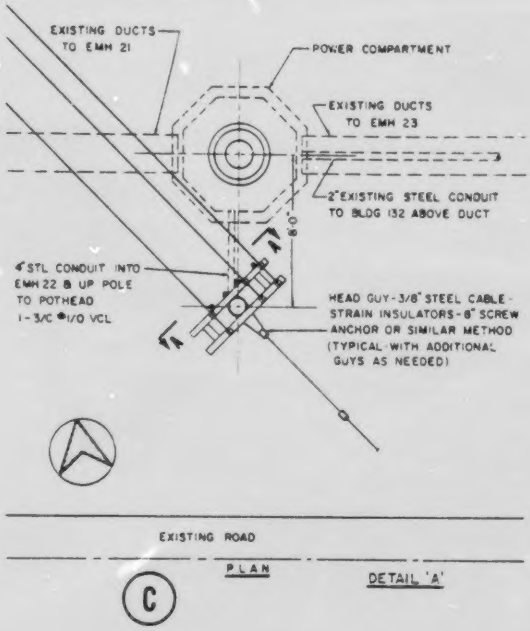
3 - INSULATORS TO BE PORCELAIN, PIN TYPE. INSULATOR PINS TO BE LOCUST WOOD OR EQUAL

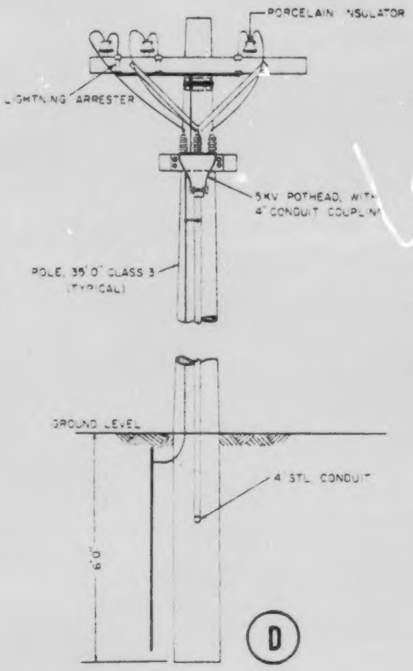
4 - TERMINAL POLES, AND POLES AT POINT OF CHANGE IN LINE DIRECTION, TO HAVE DOUBLE CROSS-ARMS. ALL OTHER POLES, SINGLE CROSS-ARM. CROSS-ARMS TO BE STANDARD 4 PIN, 5'-7" x 3 1/2" x 4 1/2", PIN SPACING 3'-0" ON CENTERS AND 14 1/2" ON SIDES

5 - TERMINAL POLES TO HAVE ONE GUY, POLES AT POINT OF CHANGE IN LINE DIRECTION TO BE GUYED ACCORDING TO STANDARD PRACTICE. EACH GUY LINE TO HAVE TWO PORCELAIN STRAIN INSULATORS. THE LOCATION AND SPACING OF STRAIN INSULATORS AND GUY ANCHORS TO BE IN ACCORDANCE WITH STANDARD PRACTICE

6 - MATERIAL AND WORKMANSHIP SHALL CONFORM TO ALL STANDARD CODES, REGULATIONS AND SPECIFICATIONS LISTED IN BUREAU OF YARDS AND DOCKS SPECIFICATION NO. 9Y1

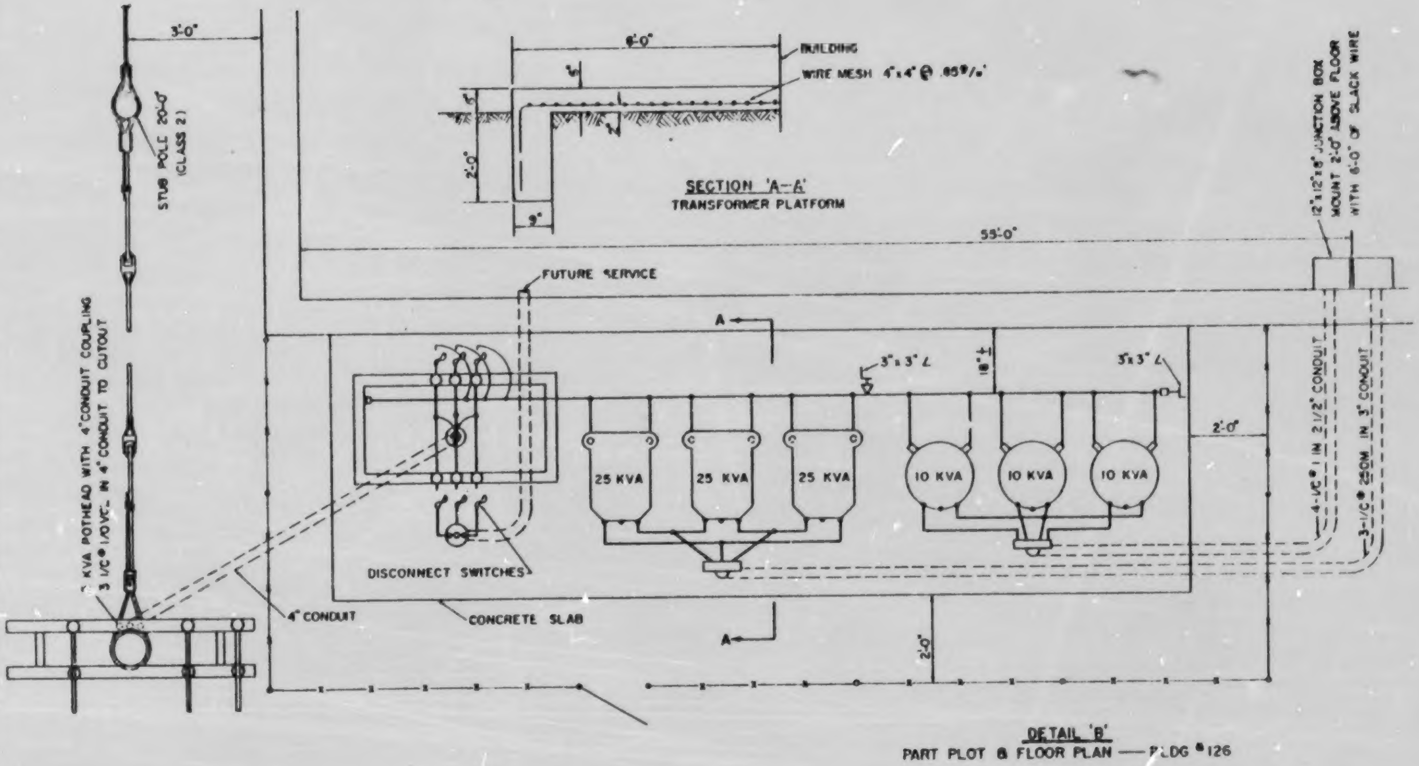
B


EXISTING DUCTS TO EMH 21
POWER COMPARTMENT
EXISTING DUCTS TO EMH 23
2" EXISTING STEEL CONDUIT TO BLDG 132 ABOVE DUCT
8'-0"
4" STL CONDUIT INTO EMH 22 & UP POLE TO POTHEAD 1-3/C #1/0 VCL
HEAD GUY - 3/8" STEEL CABLE - STRAIN INSULATORS - 8" SCREW ANCHOR OR SIMILAR METHOD (TYPICAL WITH ADDITIONAL GUYS AS NEEDED)
EXISTING ROAD
PLAN
DETAIL 'A'
C


PORCELAIN INSULATOR
LIGHTNING ARRESTER
5KV POTHEAD, WITH 4" CONDUIT COUPLING
POLE, 35'0" CLASS 3 (TYPICAL)
GROUND LEVEL
4" STL CONDUIT
6'-0"
D

65.67

Figure 2-7.—Plot plan with electrical layout, general notes, detail and section drawings.


3'-0"
STUB POLE 20'-0" (CLASS 2)
? KVA POTHEAD WITH 4" CONDUIT COUPLING 3 1/C # 1/0VC. IN 4" CONDUIT TO CUTOUT
6'-0"
BUILDING
WIRE MESH 4"x4" @ .85#/□'
5"
2'-0"
9"
SECTION 'A-A'
TRANSFORMER PLATFORM
55'-0"
12"x12"x6" JUNCTION BOX MOUNT 2'-0" ABOVE FLOOR WITH 6'-0" OF SLACK WIRE
FUTURE SERVICE
A
3"x3" ∠
18"±
3"x3" ∠
2'-0"
25 KVA
25 KVA
25 KVA
10 KVA
10 KVA
10 KVA
4-1/C # 1 IN 2 1/2" CONDUIT
3-1/C # 250M IN 3" CONDUIT
DISCONNECT SWITCHES
4" CONDUIT
CONCRETE SLAB
A
2'-0"
DETAIL 'B'
PART PLOT & FLOOR PLAN — BLDG # 126

65.69

Figure 2-8.—Detail B indicated in figure 2-7.

information which they furnish on proper installation of equipment and operating procedures will furnish satisfactory answers to many installation problems.

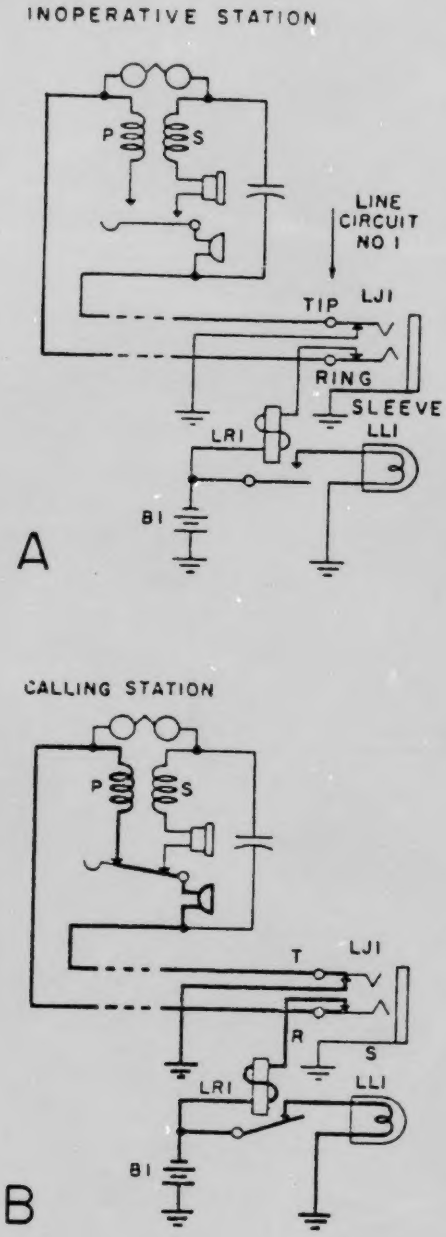
These standard drawings prepared by NavFac can save a surprising amount of time in the erection of a number of similar structures, and in wiring them for heating and lighting. For example, if a series of quonsets are to be erected, use of a standard plan enables the man in charge to put the various tasks on an assembly-line basis, and makes it possible to erect an entire quonset town in less time than it would to build an ordinary house.

However, a single master plan cannot be used for all buildings. Changes are often necessary because of the use of the building and the type of machinery to be installed. Where shops are being erected, there will probably be at least one standard drawing for each type of shop.

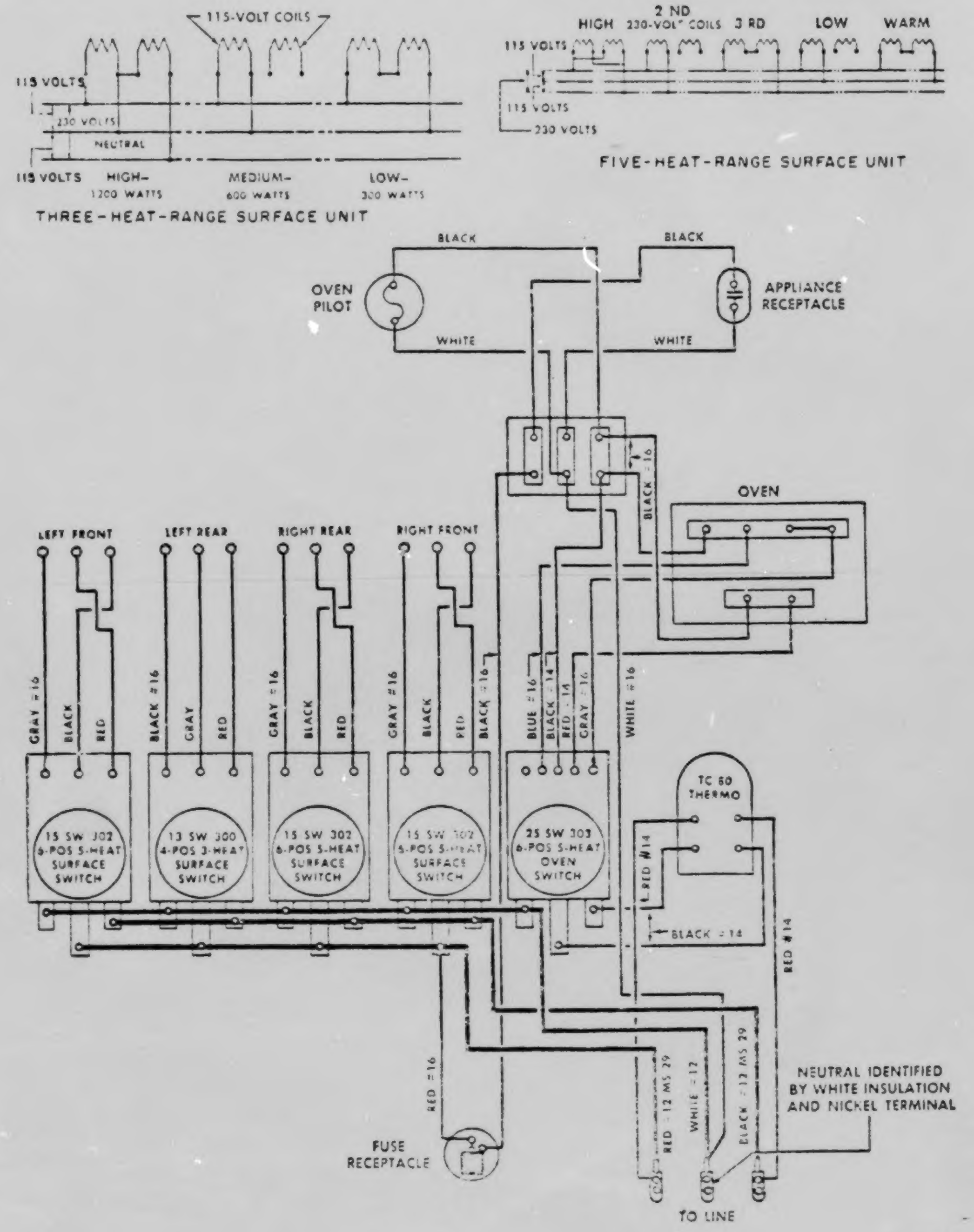
Whatever the number or type of drawings available, they must furnish the Construction Electrician with the following information; layout and space arrangement; necessary machinery, equipment, and materials; list of any reference drawings; and notations about changes made in standard drawings to fit particular buildings.

CONCLUSION

Your ability to read and interpret intelligently the variety of plans, schematics, and diagrams described in this chapter should also enable you to work more safely and efficiently on any part of any electrical system and improve your promotion possibilities.



73.270
Figure 2-11.—Line circuit portion of switchboard.

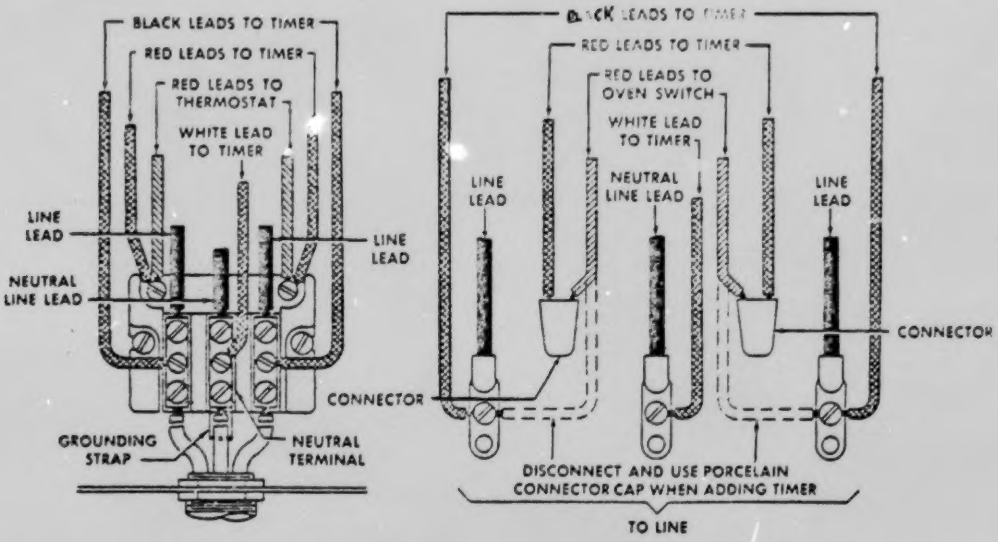

115-VOLT COILS
115 VOLTS
230 VOLTS
NEUTRAL
115 VOLTS
HIGH–
1200 WATTS
MEDIUM–
600 WATTS
LOW–
300 WATTS
HIGH
2 ND
230-VOLT COILS
3 RD
LOW
WARM
115 VOLTS
115 VOLTS
230 VOLTS
BLACK
BLACK
OVEN PILOT
APPLIANCE RECEPTACLE
WHITE
WHITE
BLACK #16
OVEN
LEFT FRONT
LEFT REAR
RIGHT REAR
RIGHT FRONT
GRAY #16
BLACK
RED
BLACK #16
GRAY
RED
GRAY #16
BLACK
RED
GRAY #16
BLACK
RED
BLACK #16
BLUE #16
BLACK #14
RED #14
GRAY #16
WHITE #16
15 SW 302 6-POS 5-HEAT SURFACE SWITCH
13 SW 300 4-POS 3-HEAT SURFACE SWITCH
15 SW 302 6-POS 5-HEAT SURFACE SWITCH
15 SW 302 5-POS 5-HEAT SURFACE SWITCH
25 SW 303 6-POS 5-HEAT OVEN SWITCH
TC 60 THERMO
RED #14
BLACK #14
RED #14
RED #16
RED #12 MS 29
WHITE #12
BLACK #12 MS 29
NEUTRAL IDENTIFIED BY WHITE INSULATION AND NICKEL TERMINAL
FUSE RECEPTACLE
TO LINE

THREE-HEAT-RANGE SURFACE UNIT

FIVE-HEAT-RANGE SURFACE UNIT

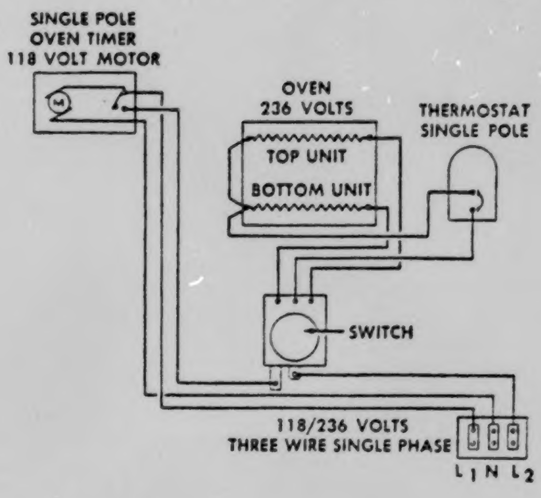
73.271

Figure 2-12.—Range wiring diagrams.


BLACK LEADS TO TIMER
RED LEADS TO TIMER
RED LEADS TO THERMOSTAT
WHITE LEAD TO TIMER
LINE LEAD
NEUTRAL LINE LEAD
LINE LEAD
CONNECTOR
GROUNDING STRAP
NEUTRAL TERMINAL
BLACK LEADS TO TIMER
RED LEADS TO TIMER
RED LEADS TO OVEN SWITCH
WHITE LEAD TO TIMER
LINE LEAD
NEUTRAL LINE LEAD
LINE LEAD
CONNECTOR
DISCONNECT AND USE PORCELAIN CONNECTOR CAP WHEN ADDING TIMER
TO LINE

73.272

Figure 2-13.—Representative wiring diagrams for range timer connections.


SINGLE POLE OVEN TIMER 118 VOLT MOTOR
M
OVEN 236 VOLTS
TOP UNIT
BOTTOM UNIT
THERMOSTAT SINGLE POLE
SWITCH
118/236 VOLTS THREE WIRE SINGLE PHASE
L1 N L2

73.273

Figure 2-14.—Representative diagram of electric-range single-pole oven timer.

CHAPTER 3

SAFETY

All electrical systems are potential KILLERS. All personnel should be aware of their potential dangers. CEs especially should have complete knowledge of the inherent and man-made electrical hazards because they WORK on electrical equipment or systems. But safety applies to more than electrical equipment or systems. The entire construction field requires constant alertness to a variety of hazards which are always present.

In this chapter, we will examine some of these hazards and basic safety precautions, remembering that many of the rules and regulations instituted over the years are direct results of attempts to reduce accidents, pain, and anguish. Remember, many men learned some of these rules the hard way.

Your adherence to these basic safety practices will minimize danger to life and equipment. Furthermore, your knowledge of first-aid, and your ability to use it correctly, may save someone's life in an emergency. FOR YOUR OWN BENEFIT, LEARN THIS LESSON WELL!

ELECTRICAL SHOCK CAUSES AND CONSEQUENCES

Most fatal electric shocks do not happen to the uninitiated—they happen to people who should know better. As a Construction Electrician, carelessness in your work can sentence you to death by electrocution. Familiarity with the equipment tends to make you forget the little precautions taught in trade school.

After an accident, particularly a fatal one, safety rules are restressed for the benefit of all hands. Unfortunately it is impossible to bring the dead back to life or change the results of the accident; that is why it is necessary, even at the risk of monotony, to constantly stress or even preach SAFETY. It may make you think twice before taking that last chance.

Most of us are apt to remember only the most important safety precautions, but how many of us stop to think of the small details that really INSURE safety? Also, how many of us realize it is the current, not the voltage, that is lethal?

Although the sign "Caution—High Voltage" serves as a reminder to keep hands off, don't forget that an electric shock from 10,000 volts is no more deadly than a shock from ordinary 115-volt "house" current. Industrial equipment using as little as 12 volts of direct current has been fatal (30 volts a.c. is considered hazardous). CURRENT, NOT VOLTAGE, IS THE LETHAL AGENT.

The seriousness of an electric shock depends upon the magnitude of the current flow in the victim. Current flow in turn depends upon the electrical resistance of the circuit path through the victim's body. This can vary considerably depending upon the degree of contact and the skin resistance at the time of contact.

We are all aware of the presence of moist skin caused by perspiration on a hot day, but few of us think about the sudden moistening of the skin when we are frightened or startled. The unexpected discharge of a capacitor or the inadvertent shorting of a voltage point when troubleshooting often will startle the technician, make him jump, and at the same time bring on a momentary "cold sweat." Such reactions are not uncommon and obviously they set up a shocking situation (no pun intended).

Although this may be considered an extreme case, it does illustrate how an individual's resistance can vary considerably from minute to minute depending upon his emotional state at the instant of contact. Skin resistances of a few hundred ohms when wet to well over 500,000 ohms when dry have been measured, so be careful—take every safety precaution possible—it may save your life.

Figure 3-1 illustrates what a person may expect when he is subjected to increasing (current) electric shock. His first reaction occurs when the current is only 2- or 3-milliamps. At 10 milliamps, the shock is no longer a mild tingling sensation but becomes painful. As the current flow increases beyond 20 milliamps, muscular paralysis begins and the victim cannot release the contact. In the range from 50 to 100 milliamps, breathing becomes difficult—in fact it often stops. Between 100 and 200 milliamps,

CHAPTER 4

TEST EQUIPMENT

As a Construction Electrician, you will be required to place new electrical equipment into operation, repair defective equipment, and perform routine preventive maintenance. To help you accomplish these jobs efficiently, many test equipments are available. Some of these may appear to be complex. When analyzed, however, their theories and techniques of operation may be reduced to simple basic circuits and procedures.

This chapter will describe test procedures and equipments used for investigating a variety of difficulties. You will be able to repair vital equipment expeditiously and safely when you follow correct test procedures and instructions as you use the instruments.

The purpose of these instruments is to test and measure accurately certain circuit values or to determine the operating condition of the electrical circuits. Their accuracy depends on their design and how the instruments are treated.

The operating energies involved in electrical measuring instruments are extremely small. The instruments themselves are necessarily of delicate construction and special precautions in handling and use to obtain accurate results and to avoid injury by mechanical shock, exposure to strong magnetic fields, and excessive flow are necessary. One of your major responsibilities is to take care of any instruments assigned to you. Instructions and wiring diagrams are furnished with instruments. Such instructions are either attached to the instrument case or cover, or are given in separate instruction books. These should be consulted freely for specific instructions and precautions.

Among the newer types of test equipment presently being distributed to the battalions and shore stations are the MS-1A Multi-Amp relay and circuit breaker tester, and the Servivar electrical test set. You undoubtedly recognize the importance of becoming familiar with any test equipment capable of performing special tests. Knowledge of these instruments will enable you to place equipment into operation quickly and safely.

POWER TEST EQUIPMENT

While some test equipment is specifically designed to either electrical power or communication equipment much test equipment can be used for both. Therefore, description of the instruments discussed under this heading do not necessarily imply that the equipment cannot be used in the communication field.

BASIC MEASURING INSTRUMENT PRECAUTIONS

As a Construction Electrician Third or Second Class, you must know about the types and functions of ammeters, voltmeters, and ohmmeters. Information regarding these basic measuring devices may be found in Basic Electricity, NavPers 10086-B.

When using measuring instruments certain precautions must be observed. For example, it is especially important to be careful in using an ammeter because of its low internal resistance. If mistakenly placed across a voltage source, the meter can be damaged. Always break the circuit and CONNECT AN AMMETER IN SERIES, with one meter lead going to each point of the circuit break to measure an unknown quantity. Be sure to deenergize the circuit before making or breaking the connections.

When using either ammeters or voltmeters, ALWAYS start at the HIGHEST meter range. Then drop down to a lower scale range if necessary. This practice protects the meter from injury if an attempt is made to read a high value in a low range. Damage to instruments can also be minimized if you form the habit of placing the range selector switch in the highest range position after you have finished using the instrument.

OBSERVE POLARITY on all direct current measurements. Take care to connect the positive terminal of the source to the positive terminal of the meter, and the negative terminal of the source to the negative terminal of the meter. This ensures that the meter polarity matches

816

the polarity of the circuit in which the meter is placed.

Be careful to avoid dropping a meter or subjecting it to excessive mechanical shock. Such treatment may damage the delicate mechanism or cause the permanent magnet to lose some of its magnetism.

Care must be taken to avoid connecting the ohmmeter across circuits in which a voltage exists, since such connection can result in damage to the instrument. TO ENSURE THE REMOVAL OF ALL VOLTAGE TO THE EQUIPMENT UNDER TEST, DISCONNECT THE SOURCE OF INPUT VOLTAGE BY REMOVING THE POWER PLUG. Furthermore, ALL CAPACITORS MUST BE DISCHARGED before the ohmmeter prods are connected in the circuit. Charges remaining on capacitors after the applied voltage has been removed can damage the instrument severely.

Always turn ohmmeters OFF when finished. This will avoid discharge of the internal battery if the test leads are shorted inadvertently.

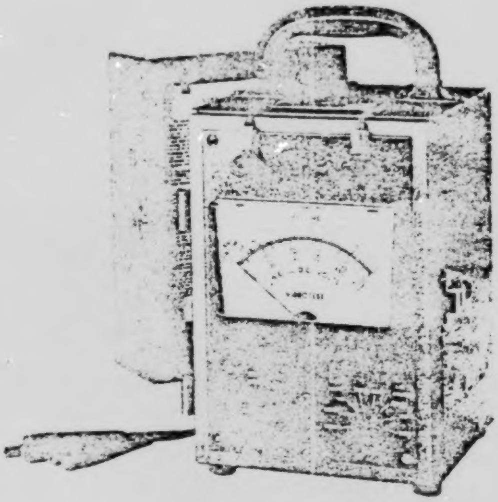
It is important that you remember to USE A LOW VOLTAGE MEGGER TO TEST LOW VOLTAGE INSULATION. Application of high voltage may initiate insulation breakdown. LOW VOLTAGE MEGGERS should not be used to test high voltage insulation because an inaccurate reading may result from the comparatively small output voltages available from this instrument. Be careful, whether using high or low range meggers. Dangerous voltages exist at meter terminals and leads.

VIBROTEST MEGOHMMETER

Figure 4-1 shows the Vibrotest Megohmmeter. It is used as an insulation measuring instrument primarily, but can also be used as an a.c. and d.c. voltmeter. It is a multipurpose instrument that does not require cranking. A vibrator and transformer develop the voltages required for insulation measurements. Special circuitry reduces surface leakage interference for more accuracy.

Records kept of the various insulation readings taken at the appropriate intervals will help you spot potential insulation breakdowns before consequent damage to equipment or personnel occurs.

CAUTION: It is imperative to remember that a high voltage exists across the terminals when testing in the megohm ranges.



1.55(26D)BX

Figure 4-1.—Vibrotest megohmmeter.

The following diagrams and brief descriptions will show you how to determine insulation resistance in a variety of electrical apparatus. BE SURE YOUR EQUIPMENT OR WIRING IS DEENERGIZED.

Cable Insulation Checks

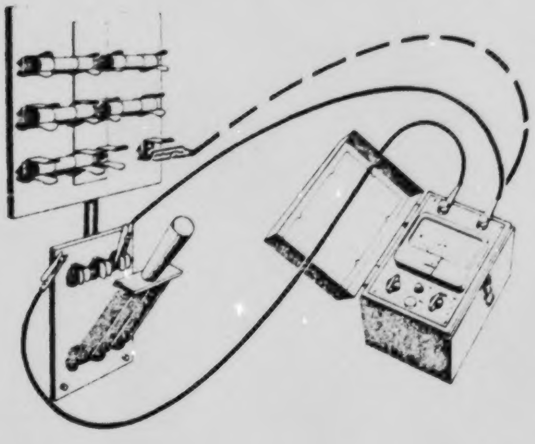
Where you have an ungrounded distribution panel, you can check insulation of the whole wiring system to ground by attaching one test lead to the dead post of the open main power switch and the other lead to a ground (fig. 4-2).

Individual circuits are tested to ground by opening distribution panel switches or fuses and testing each circuit in turn (fig. 4-2, broken lead).

Multi-conductor cables may be tested in any of the ways shown in figure 4-3. The drawing depicts the measurement of insulation resistance between wire (3) and lead sheath (5). Various other measurements can be made such as wire to ground (1, 2 and/or 3 to 6), wire to wire (1, 2 or 3 to any combination of each other), wire to braid (1, 2, or 3 to 4), wire to sheath (1, 2 and/or 3 to 5).

It is well to remember that when you test wiring which is connected to any panel or equipment, there may be appreciable leakage between

1165

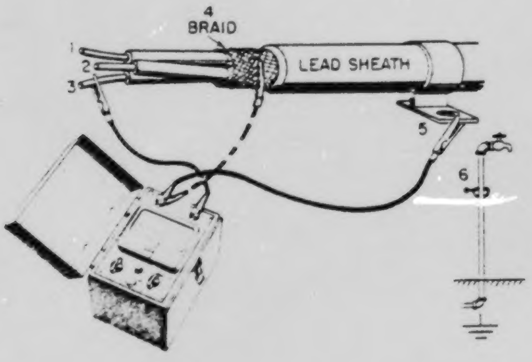


73.277X
Figure 4-2.—Testing a distribution panel and its individual circuits.

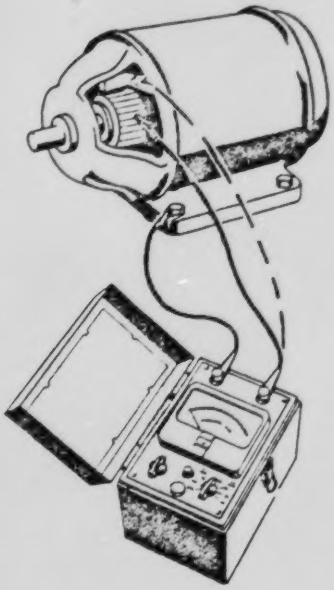
terminals which will show up in your tests as lowered insulation resistance. If your original record cards were made with panels connected, continue future tests in the same manner.

Checking Motors and Generators

As you know, the bases, frames and enclosures of electrical equipment must be grounded. The megohmmeter is used to verify that the windings associated with the various components of motors and generators aren't grounded and are properly insulated (figs. 4-4 and 4-5).



73.278X
Figure 4-3.—Testing multiple conductor cables.

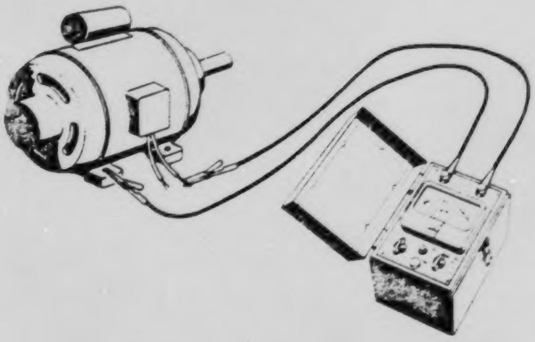


73.279X
Figure 4-4.—Testing direct current motors and generators.

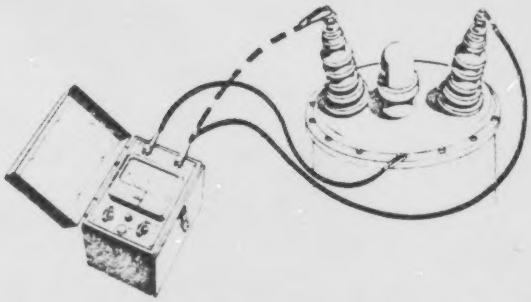
Before you make any tests, BE SURE TO DISCONNECT THE MOTOR OR GENERATOR FROM THE LOAD and SOURCE.

Circuit Breaker and Switch Insulation Tests

Figure 4-6 depicts the measurement of insulation resistance between either circuit



73.280X
Figure 4-5.—Testing alternating current motors.



73.281X

Figure 4-6.—Checking circuit breaker insulation resistance.

breaker terminal to ground. This measurement should also be made between terminals. If your breakers are of the oil type, dirty oil may be causing leakage currents through the breaker even when it is open. Dirt or grease in the mounting may be causing leakage in the dry type. Switches and circuit breakers must be COMPLETELY disconnected from line and relay wiring before testing.

Insulators

Insulators, the "forgotten men" of electrical systems, are subject to several ills that can make them a potential hazard unless they are periodically tested. Breakage is probably the first hazard with insulators. Casually accumulated dirt, grease, or liquids is another. Rarely, faulty construction makes a brand new insulator a source of danger. To test insulators, connect test leads to each end; then test each end to ground (fig. 4-7, left half).

Capacitors

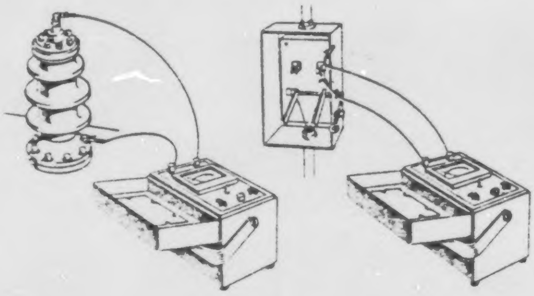
You can use this instrument to check both insulation resistance and approximate capacitance of capacitors. When you connect leads to capacitor terminals, observe polarity carefully. Time your test until meter pointer stops moving upward, then record insulation resistance at highest reading. Dividing test time, in seconds, by 15 will give you the approximate capacitance, in microfarads, of the capacitor. If one pointer has a tendency to waver toward the high reading, then drop back down the scale. The capacitor may be leaking, and further testing is indicated. Be especially careful to RELEASE PUSH-BUTTON before starting to disconnect test leads from capacitors. If you do not give the Vibrotest discharge resistor an opportunity to dissipate the stored potential in the capacitor, you may get a severe shock.

Transformers

Deenergize equipment. Disconnect the leads from both primary and secondary windings. Tests can be made of either the primary or secondary winding individually by connection of the negative lead to an associated ground (case, metal mounting, or man-made ground), and the lead from the winding under test to the positive lead. Following tests of each winding, it is a good idea to test insulation resistance between the windings themselves. Connect one test lead to the primary (either lead); and the second test lead to the secondary. All of these tests, under proper identifying labels, should be recorded on a record card.

If you have transformers with multiple-voltage windings, the procedures above should be followed to test all windings to ground, and each winding's resistance value to every other winding.

Tests should be made during clear, dry weather. The temperature and relative humidity of the air and general atmospheric conditions should be recorded at the time tests are being made, if known. Test records should be kept since they show when trouble is developing as a result of gradual or sudden deterioration of the insulation or because of local leakage. For example, a 40-megohm reading on the primary



73.282X

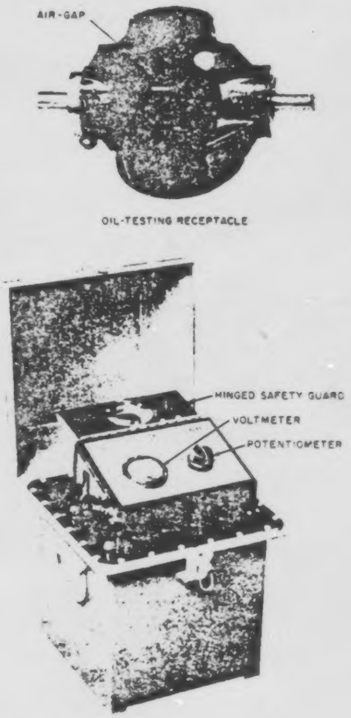
Figure 4-7.—Testing insulators and switches.

winding of a transformer that has been testing about 500 megohms indicates trouble that should be remedied. Low resistance values may require oil samples to be taken from the transformer to determine whether or not the low values may be due to deterioration of the oil.

PORTABLE OIL TESTER

Let's assume that your chief asks you to verify the condition of the oil in the transformer. How will you accomplish this task?

Figure 4-8 shows a representative oil tester. Adjustments of the air-gap in the oil-testing receptacle are made according to the specifications in the instruction manual. Your sample oil is then added to the porcelain receptacle and covered by the hinged safety guard. For a more accurate reading, wait until air bubbles formed when pouring oil disappear. The instrument is then plugged into a power source and increasing voltage applied until breakdown occurs via the preset air-gap. Careful notation of the voltmeter indication at the time of breakdown is made. Three readings should be obtained. If the resultant breakdown average is below 22,000 volts, replacement of the oil is indicated. Normally, insulation breakdown of the oil beyond 22,000 volts is satisfactory, but breakdown above 26,000 volts is preferred.



73.283X
Figure 4-8.—35,000 volt portable oil tester.

POWER CIRCUIT ANALYZER

A power circuit or industrial analyzer (fig. 4-9) is designed for alternating current only and should not be used on direct current.

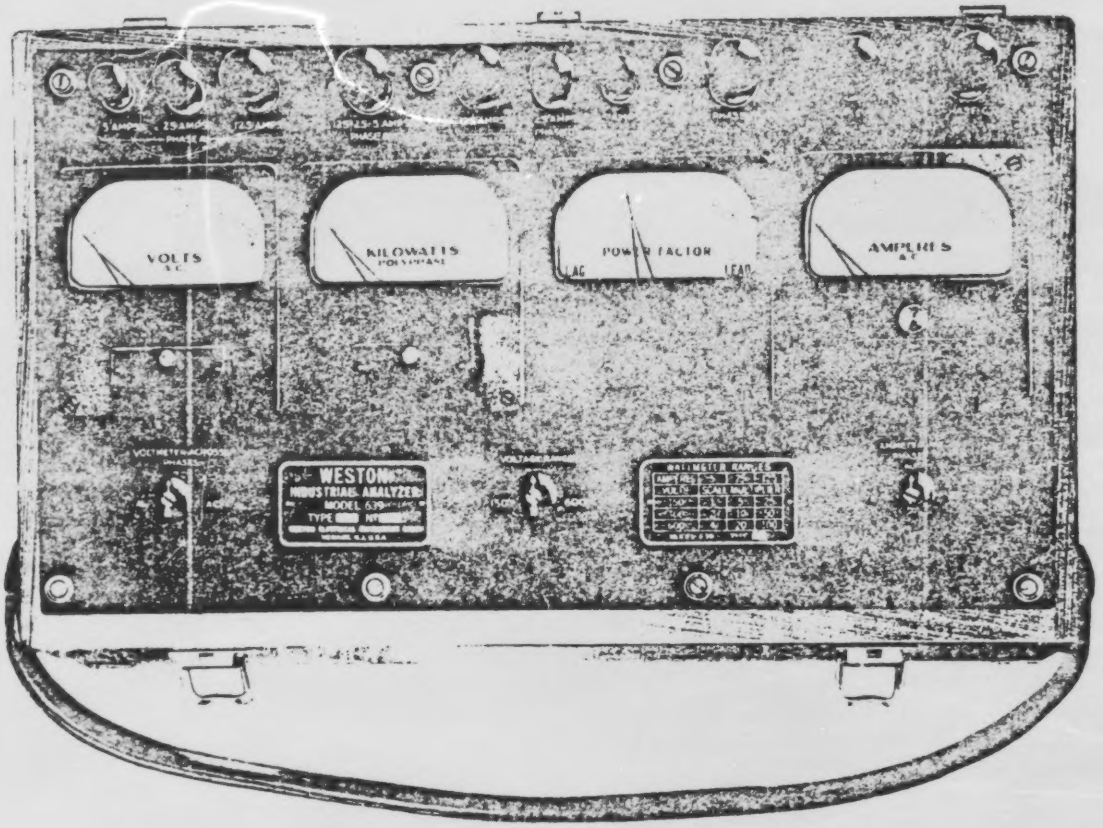
The analyzer consists of a voltmeter, ammeter, wattmeter, power factor meter, two current transformers, and the necessary switches enclosed in one case to facilitate the testing of three-phase, 3-wire loads.

Although the analyzer has been designed primarily for three-phase, 3-wire loads, it can be used for measurements on single-phase and polyphase circuits.

When testing other than a balanced three-phase, 3-wire load, the indications of the power factor meter should be disregarded.

Before connecting the analyzer, it is advisable to set the voltage range changing switch to the 600 volt range unless the voltage to be measured is definitely known to be suitable for a lower range.

One ampere flowing through the meter movement will provide full-scale deflection. Larger currents being measured must be reduced by appropriate use of the current transformers or additional shunts as required.



26.29X

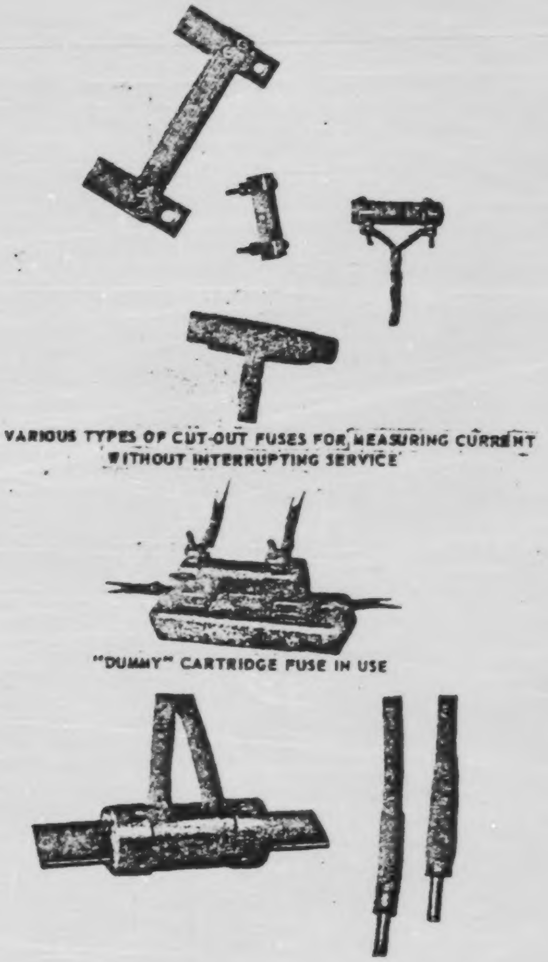
Figure 4-9.—A.C. power circuit analyzer.

Connecting Analyzer to Circuits

All cables used for connections to source or load should be of sufficient size to carry the currents involved and connected securely to the binding posts and the circuit terminals. Refer to Table 310-13 (NEC) for information regarding the allowable ampacities of insulated copper conductors, for more data pertaining to cables.

BE SURE TO USE THE APPROPRIATE CORRECTION FACTOR (bottom of Table 310-13) wherever the ambient temperature exceeds 86° F. For example, if you plan to use THW conductor, and the ambient temperature at your station is 113° F., recognize that the current carrying capacity of the size of wire you intend to use will be reduced 18 percent and be equivalent to 82 percent of that listed in Table 310-13.

The most convenient place to make connections is at the fuse block, by using dummy fuses with cables attached (fig. 4-10). The cables connected to these dummy fuses may be connected to the analyzer. When an interruption to service will be convenient, it is only necessary to remove the good fuses from the cutout and insert the dummy fuses with cables attached. CAUTION: Disconnect the circuit by opening the main line switch before removing fuses and inserting dummy fuses. This may be done very quickly. This method is only a suggestion and may not always be practical. When using this method be certain that the circuit is protected


VARIOUS TYPES OF CUT-OUT FUSES FOR MEASURING CURRENT WITHOUT INTERRUPTING SERVICE
"DUMMY" CARTRIDGE FUSE IN USE

26.31X
Figure 4-10.—Various types of "dummy" fuses.

by other fuses or circuit breakers as these dummy fuses remove the protection at that point.

Testing Single-Phase Loads

The diagrams of connections shown in figures 4-11, 4-12, and 4-13 may be used for 2-wire circuits.

Note in the figures mentioned above that a connection is made on the analyzer from the C to the A phase, to get as great a deflection of the wattmeter movement as possible.

For single-phase, 3-wire circuits, the connections are the same as the three-phase, 3-wire connections.

Three-Phase 3-Wire Loads

Figure 4-14 and 4-15 show the connections necessary for all three-phase, 3-wire testing. The readings of the wattmeter are correct regardless of unbalance or power factor of the load. The readings of the power factor meter are correct for any current down to 1/5 of the full scale value.

Three-Phase 4-Wire Loads

As mentioned earlier, the analyzer was designed primarily for three-phase, 3-wire loads; therefore, when three-phase, 4-wire loads are to be analyzed certain limitations are to be expected.

1. The power factor meter readings on three-phase 4-wire loads should be disregarded.
2. The voltmeter readings will be "line-to-neutral" and "line-to-line" voltages depending upon position of voltage-selector switch.
3. External current transformers must ALWAYS be used. (See fig. 4-16.)

If the three-phase, 4-wire load is balanced, with no current in the neutral wire, it may be treated as outlined for a three-phase 3-wire load and the above limitations should be disregarded.

Regardless of the balance, each phase may be treated as a single-phase load and tested accordingly. External current transformers should have the same ranges as the transformers contained in the analyzer, that is, 125, 25, or 5 amperes.

Instrument Readings, Corrections, and Connections

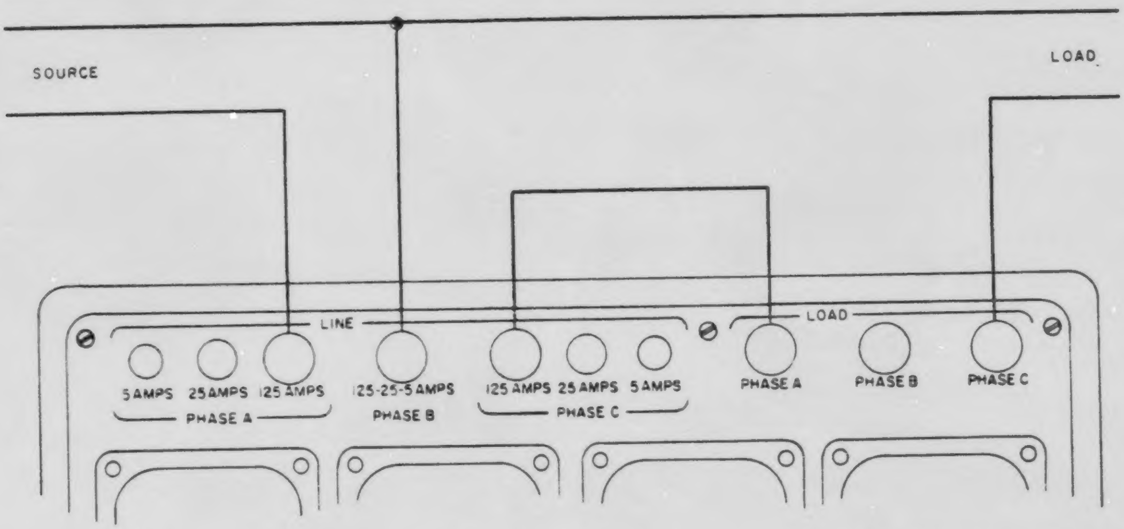
The readings of the voltmeter (fig. 4-9), using proper range and scale, represent the following:

With switch at AB, the voltage from line A to line B.

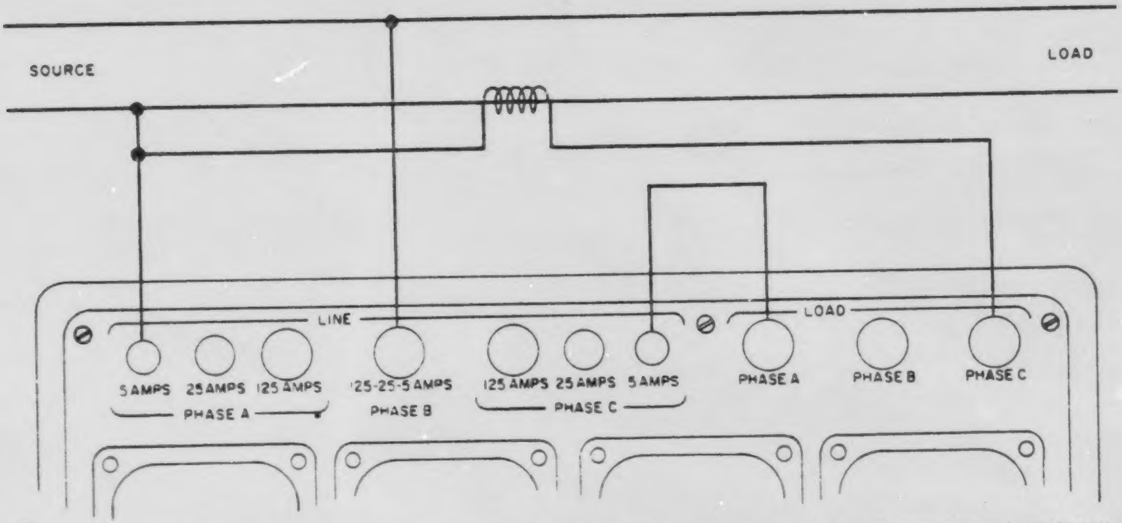
With switch at BC, the voltage from line B to line C.

With switch at AC, the voltage from line A to line C.

The wattmeter readings must be corrected by the multiplying factors found on the wattmeter scale.


SOURCE
LOAD
LINE
LOAD
5 AMPS
25 AMPS
125 AMPS
PHASE A
125-25-5 AMPS
PHASE B
125 AMPS
25 AMPS
5 AMPS
PHASE C
PHASE A
PHASE B
PHASE C

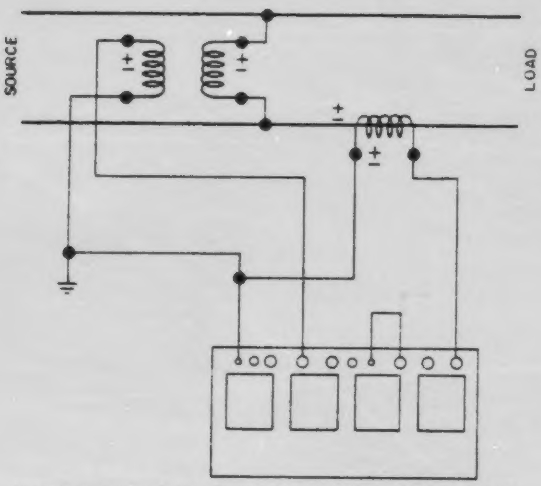
A SINGLE PHASE, 2 WIRE CIRCUIT. BOTH ELEMENTS OF WATTMETER IN SERIES. READ VOLTAGE AB, CURRENT A, APPLY THE WATTMETER MULTIPLIER AS FOUND ON THE WATTMETER SCALE AND THEN DIVIDE BY 2. DISREGARD THE POWER FACTOR INDICATION.


SOURCE
LOAD
LINE
LOAD
5 AMPS
25 AMPS
125 AMPS
PHASE A
125-25-5 AMPS
PHASE B
125 AMPS
25 AMPS
5 AMPS
PHASE C
PHASE A
PHASE B
PHASE C

B USING A SINGLE CURRENT TRANSFORMER AND WITH TWO CURRENT ELEMENTS IN SERIES, READ VOLTAGE AB AND CURRENT A USING 5 AMPERE SCALE AND APPLYING TRANSFORMER MULTIPLIER. DIVIDE KILOWATT READING ON 5 AMPERE AND CORRESPONDING VOLTAGE SCALE BY 2; THEN APPLY TRANSFORMER MULTIPLIER. DISREGARD POWER FACTOR INDICATION.

26.32X

Figure 4-11.—Single-phase, 2-wire circuit connections.



READ VOLTAGE AB USING 150 VOLT RANGE AND SCALE, MULTIPLY BY POTENTIAL TRANSFORMER RATIO; CURRENT A USING 5 AMPERE SCALE AND APPLYING CURRENT TRANSFORMER RATIO. READ KILOWATTS ON SCALE CORRESPONDING TO 5 AMPERES AND 150 VOLTS THEN DIVIDE BY 2 AND MULTIPLY BY CURRENT AND POTENTIAL TRANSFORMER RATIOS.

26.33X

Figure 4-12.—Single-phase, 2-wire circuit using a current transformer and a potential transformer.

When external potential transformers are used, as shown in figure 4-17 or 4-18, the readings of the voltmeter and wattmeter should be multiplied by the potential transformer ratio in addition to the above.

When currents to be measured are beyond the range of the internal current transformers, the connections shown in figure 4-19 should be used.

The wattmeter readings must then be corrected by the multiplying factors found on the wattmeter scale and the external current and potential transformer ratios.

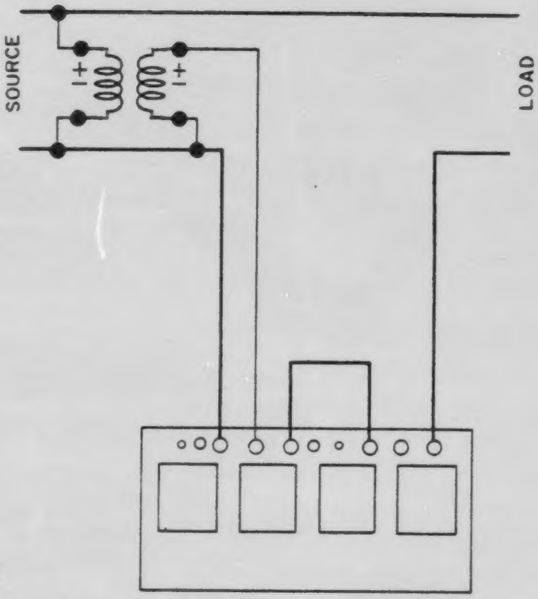
Potential connections from lines A and C are connected to the disconnect block binding posts, with the block mounted with the binding posts up.

WESTON MODEL 639 INDUSTRIAL ANALYZER TYPE 3

The Weston Model 639 Industrial Analyzer Type 3 can be used to measure the complete load conditions of any three-phase four-wire system when used with proper current and potential transformers. Switches permit testing of 60- or 400-hertz power circuits. The power factor meter and wattmeter are combined into one instrument and selection is made by another switch.

Adapters

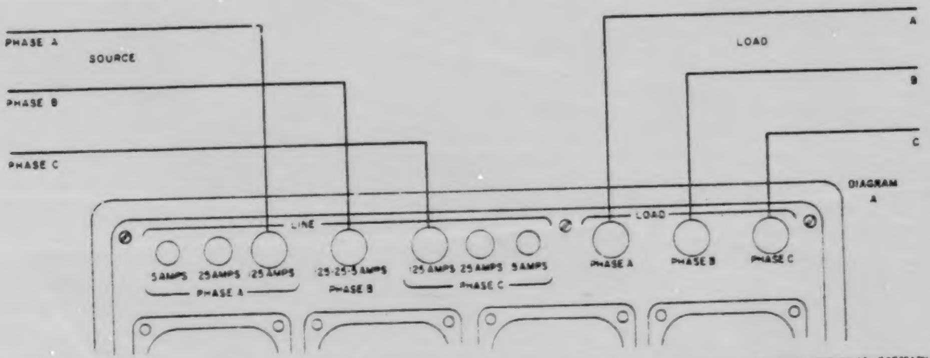
Adapters are available for use on single- and three-phase, 3-wire measurements and may expedite testing procedure. These adapters include: Model 9815 Type 1 Adapter for three-phase 3-wire 200/100/50/5-ampere operation; Model 9815 Type 2 Adapter for single-phase 2-wire 100-ampere operation; and Model 9815 Type 3 Adapter for single-phase 2-wire 50-ampere operation.



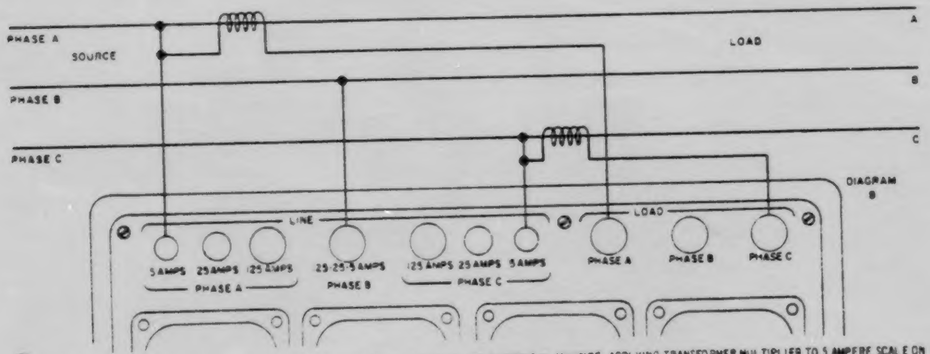
READ VOLTAGE AB USING 150 VOLT SCALE AND RANGE, MULTIPLY BY TRANSFORMER RATIO. READ KILOWATTS ON SCALE CORRESPONDING TO 150 VOLTS AND CURRENT RANGE SELECTED, DIVIDE BY 2 AND MULTIPLY BY THE POTENTIAL TRANSFORMER RATIO. READ CURRENT A USING SCALE CORRESPONDING TO RANGE SELECTED.

26.34X

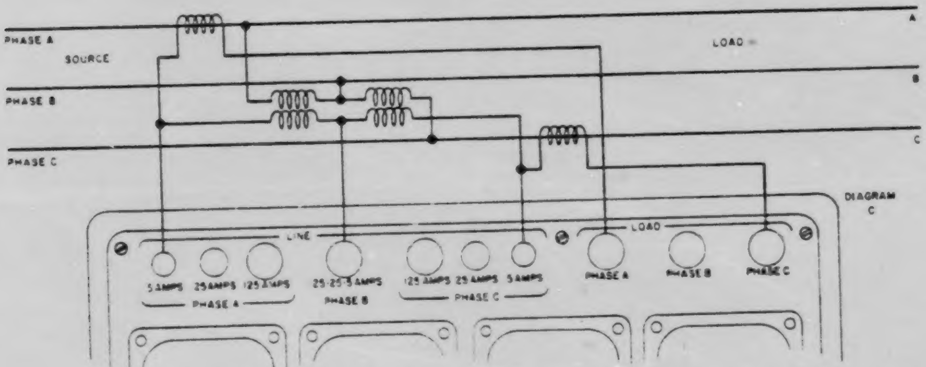
Figure 4-13.—Single-phase, 2-wire circuit using a potential transformer and with current elements in series.


PHASE A
SOURCE
PHASE B
PHASE C
LOAD
A
B
C
DIAGRAM A
LINE
LOAD
5 AMPS
25 AMPS
125 AMPS
PHASE A
125-25-5 AMPS
PHASE B
125 AMPS
25 AMPS
5 AMPS
PHASE C
PHASE A
PHASE B
PHASE C

A DIRECT. READ VOLTAGE ACROSS PHASES AS DESIRED AS WELL AS CURRENT IN ANY PHASE. APPLY MULTIPLIER AS GIVEN ON WATTMETER SCALE TO READING AS NECESSARY FOR VOLTAGE AND CURRENT RANGE USED. READ POWER FACTOR DIRECT.


PHASE A
SOURCE
PHASE B
PHASE C
LOAD
A
B
C
DIAGRAM B
LINE
LOAD
5 AMPS
25 AMPS
125 AMPS
PHASE A
25-25-5 AMPS
PHASE B
125 AMPS
25 AMPS
5 AMPS
PHASE C
PHASE A
PHASE B
PHASE C

B WITH TWO CURRENT TRANSFORMERS. READ VOLTAGE ACROSS PHASES AS DESIRED AND CURRENT IN ANY WIRE, APPLYING TRANSFORMER MULTIPLIER TO 5 AMPERE SCALE ON AMMETER. APPLY TRANSFORMER MULTIPLIER TO WATTMETER ALSO MULTIPLYING BY MULTIPLIER OF 1, 2 OR 4 DEPENDING UPON VOLTAGE RANGE AS INDICATED ON WATTMETER SCALE. READ POWER FACTOR DIRECT.

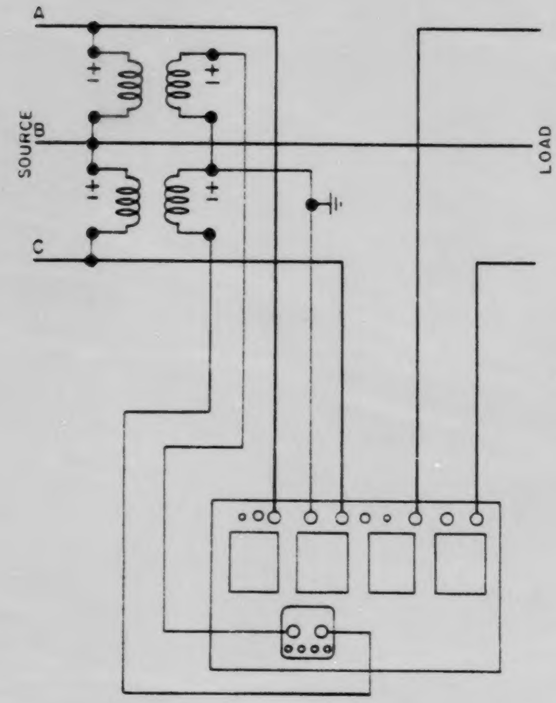

PHASE A
SOURCE
PHASE B
PHASE C
LOAD
A
B
C
DIAGRAM C
LINE
LOAD
5 AMPS
25 AMPS
125 AMPS
PHASE A
25-25-5 AMPS
PHASE B
125 AMPS
25 AMPS
5 AMPS
PHASE C
PHASE A
PHASE B
PHASE C

C USING BOTH CURRENT AND POTENTIAL TRANSFORMERS. READ VOLTAGE ACROSS PHASES AS DESIRED APPLYING POTENTIAL TRANSFORMER MULTIPLIER TO 150 VOLT SCALE TO WHICH THE VOLTAGE RANGE SWITCH SHOULD BE SET. READ AMMETER IN ANY PHASE APPLYING CURRENT TRANSFORMER MULTIPLIER TO 5 AMPERE SCALE. READ POLYPHASE WATTMETER ON 1 KILOWATT SCALE AND APPLY BOTH CURRENT AND POTENTIAL TRANSFORMER MULTIPLIERS. READ POWER FACTOR DIRECT.

26.35X

Figure 4-14.—Three-phase, 3-wire circuit hookups.

825



READ VOLTAGE ACROSS PHASE AS DESIRED. USE 150 VOLT RANGE AND APPLY POTENTIAL TRANSFORMER RATIO. READ AMMETER IN ANY PHASE DIRECT FOR RANGE SELECTED. READ WATTMETER SCALE. USE MULTIPLYING FACTOR FOR CURRENT AND POTENTIAL RANGES SELECTED. THEN MULTIPLY BY POTENTIAL TRANSFORMER RATIO.

26.36X

Figure 4-15.—Three-phase, 3-wire circuit with two potential transformers.

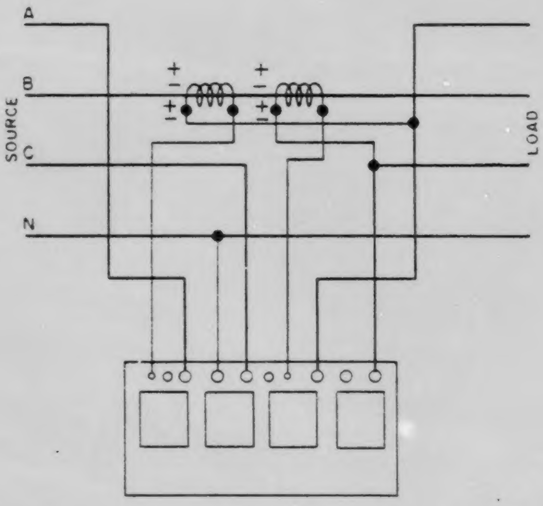
Precautions

You should remember the following precautions when using the analyzers.

1. Always set switches to the proper settings and ranges before connecting the instrument.

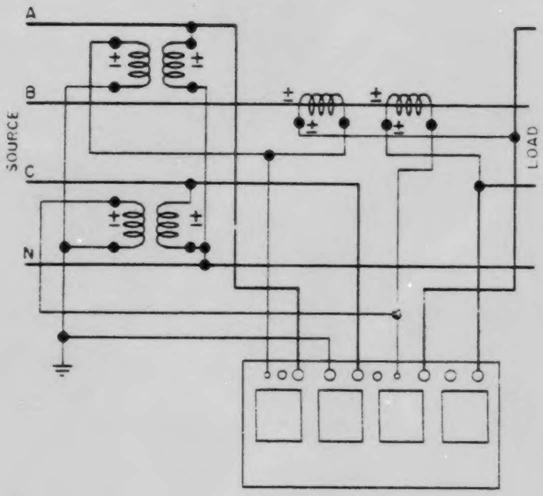
2. Always connect the load leads to the same current on all three phases of the instrument and to a high enough range so that the current indicated will be below the full scale deflection of the ammeter.

3. NEVER USE THESE INSTRUMENTS FOR D.C. MEASUREMENTS.



26.37X

Figure 4-16.—Three-phase, 4-wire circuit having identical transformers.



TWO POTENTIAL TRANSFORMERS HAVING 115 VOLT SECONDARIES, CONNECTED FROM NEUTRAL TO LINES "A" AND "C". TWO CURRENT TRANSFORMERS OF SUITABLE RANGE HAVING 5 AMPERE SECONDARIES.

26.38X

Figure 4-17.—Three-phase, 4-wire circuit with two potential transformers.

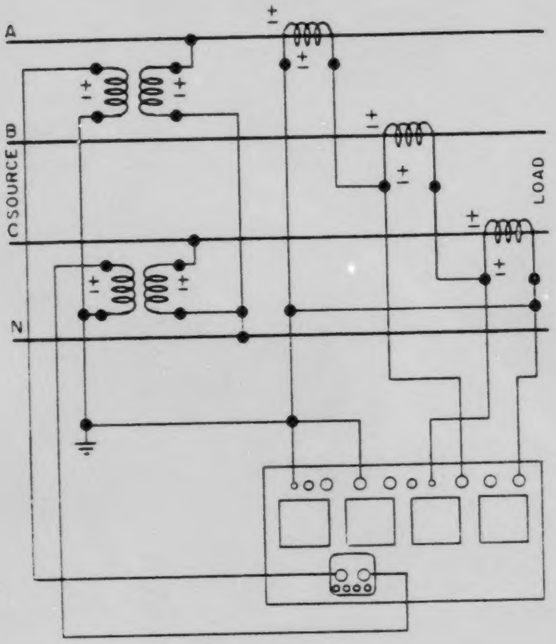
1174

MULTIAMP TESTER (MS-1A)

In a later chapter you will learn the importance of maintaining circuit breakers, relays, controllers and other protective devices in proper condition. How do we know whether or not these devices will perform as designed—to trip at rated value?

The portable device described here has as its main function exactly these purposes—to check protective devices. It checks most types of protective relays as well as small circuit breakers, fuses, and insulation resistance.

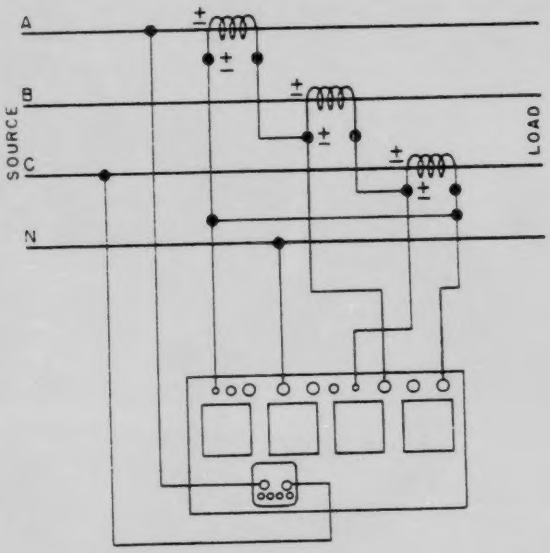
The instrument test relays from 0.1 to 100 amperes and circuit breakers up to 100 ampere capacity, measuring accurately the time-current characteristics of these devices with a synchronous electronically actuated timer.



TWO POTENTIAL TRANSFORMERS OF SUITABLE RANGE HAVING 115 VOLT SECONDARIES CONNECTED FROM NEUTRAL TO LINES "A" AND "C". THREE CURRENT TRANSFORMERS OF SUITABLE RANGE HAVING 5 AMPERE SECONDARIES CONNECTED IN DELTA.

26.40X

Figure 4-18.—Three-phase, 4-wire circuit connected to three current transformers.



POTENTIAL DIRECT CONNECTED. THREE CURRENT TRANSFORMERS OF SUITABLE RANGE HAVING 5 AMPERE SECONDARIES DELTA CONNECTED.

26.39X

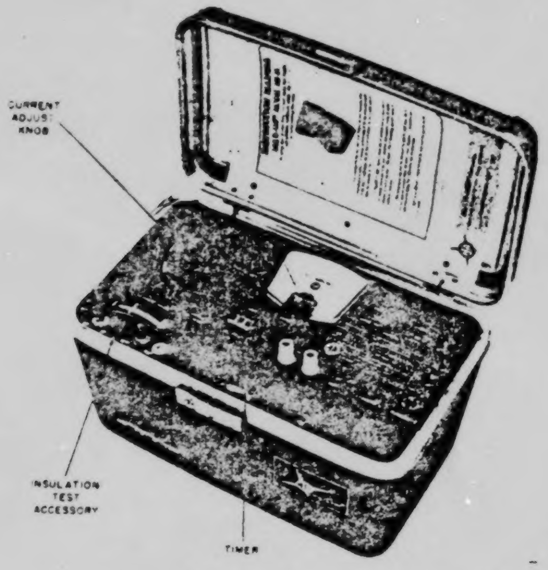
Figure 4-19.—Three-phase, 4-wire circuit with potential directly connected.

The MultiAmp (MS-1A) instrument (fig. 4-20) is used primarily in Public Works Installations. Testing is rapid. It takes but a few minutes to know your equipment is properly protected.

The instrument can be used to check the overload heaters of small motors. Refer to manufacturer's data sheets or Allowance Parts Lists for the tripping time characteristics for the particular overload heater. After setting the Current Adjust knob to that current which is supposed to trip the device and noting on the Timer the time it takes for the device to trip, a comparison is made with the manufacturer's specifications. Obviously, any results beyond the specified limits will indicate a defective relay which should be replaced or, if adjustable, reset to meet the specifications.

Use of this instrument will expedite determination of relay malfunctions or circuit faults. Assured of relay accuracy, after testing, you know the cause of difficulty (if the relay keeps tripping) lies within the circuitry other than the relay and must be sought there.

827



26.224X
Figure 4-20.—Multi-Amp model MS-1A test set.

An accessory to the MS-1A tester, used for insulation measurements, fits into the accessory socket in the test lead compartment (fig. 4-20). With it, insulation measurements from 2 to 1000 megohms with ±5 percent accuracy can be made.

MODEL 259 VIBROGROUND

Electrical systems and specific electrical equipment must be protected from damage or destruction by voltages from other circuits, or lightning. Manmade grounds provide this safety feature. To provide maximum protection, these grounds must be checked regularly.

Figure 4-21 shows the Vibroground, an instrument specifically designed to check grounds quickly and accurately.

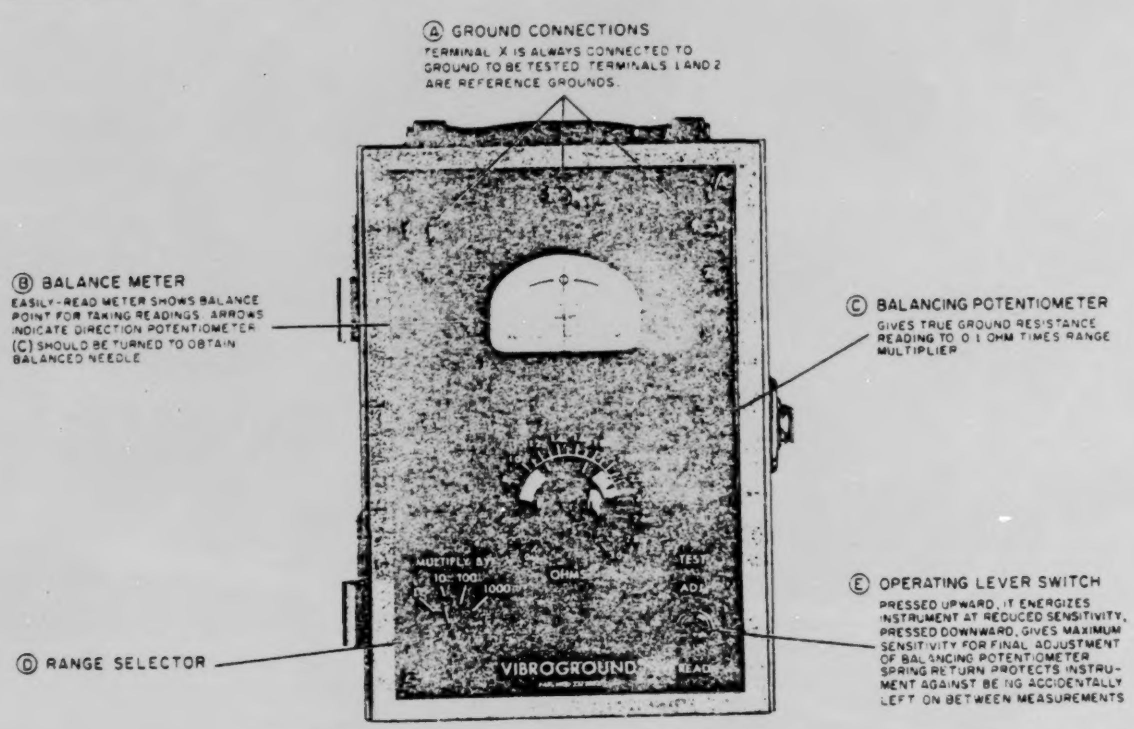
The Vibroground works on a null-balance principle. The basic circuit is indicated in figure 4-22. The voltage drop developed by a current flowing through the unknown ground resistance is measured by comparing it to a portion of the voltage drop developed by that same current flowing through a calibrated potentiometer. The current flowing through the calibrated potentiometer causes a voltage drop which is fed to the primary of the ratio transformer, inducing a voltage drop in the secondary causing a current flow in the measuring circuit. This current tends to cancel the current in the measuring circuit due to the voltage drop across the ground resistance between the electrodes connected to terminals X and 1. When the calibrated potentiometer and range switch are adjusted so that the two currents exactly cancel, the galvanometer will indicate balance by resting in the zero position. The reading on the calibrated dial of the potentiometer, multiplied by the range switch setting, then gives the value of the ground resistance of the point under test.

Representative test setups are shown in figures 4-23 and 4-24.

NavFac 9Yi says that grounding shall be in accordance with the National Electrical Code published by the National Board of Fire Underwriters and the National Electrical Safety Code published by the U.S. Department of Commerce, National Bureau of Standards, except that grounds and grounding systems shall have a resistance of solid earth ground not exceeding the following values:

	Ohms
Generating stations	1
Main substations, distribution substations, and switching stations on primary distribution system	3
Metal enclosures of electrical and electrically operated equipment and cable sheaths of connecting cables.	3
Systems to which portable electrical utilization equipment or appliances are connected	3
Secondary distribution systems (neutral), noncurrent carrying metal parts associated with distribution systems, and enclosures of electrical equipment not normally within reach of other than authorized and qualified electrical operating and maintenance personnel	10
Individual transformer and lightning arrester grounds on a distribution system.	10
Equipment not covered above	10

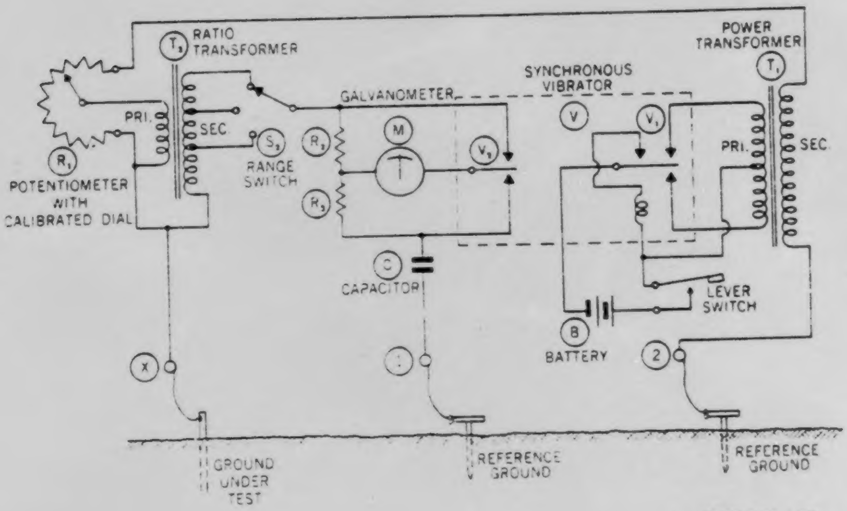
828


Ⓐ GROUND CONNECTIONS
TERMINAL X IS ALWAYS CONNECTED TO GROUND TO BE TESTED. TERMINALS 1 AND 2 ARE REFERENCE GROUNDS.
Ⓑ BALANCE METER
EASILY-READ METER SHOWS BALANCE POINT FOR TAKING READINGS. ARROWS INDICATE DIRECTION POTENTIOMETER (C) SHOULD BE TURNED TO OBTAIN BALANCED NEEDLE
Ⓒ BALANCING POTENTIOMETER
GIVES TRUE GROUND RESISTANCE READING TO 0.1 OHM TIMES RANGE MULTIPLIER
MULTIPLY BY
10
100
1000
OHMS
TEST
ADJ
READ
VIBROGROUND
Ⓓ RANGE SELECTOR
Ⓔ OPERATING LEVER SWITCH
PRESSED UPWARD, IT ENERGIZES INSTRUMENT AT REDUCED SENSITIVITY, PRESSED DOWNWARD, GIVES MAXIMUM SENSITIVITY FOR FINAL ADJUSTMENT OF BALANCING POTENTIOMETER. SPRING RETURN PROTECTS INSTRUMENT AGAINST BEING ACCIDENTALLY LEFT ON BETWEEN MEASUREMENTS

1.55(26D)AX

Figure 4-21.—Vibroground test set.

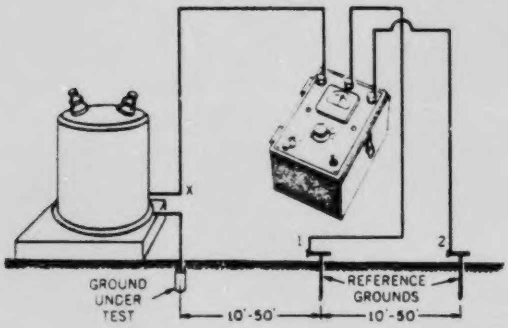
66.56


T₂ RATIO TRANSFORMER
PRI.
SEC.
S₂ RANGE SWITCH
R₁ POTENTIOMETER WITH CALIBRATED DIAL
GALVANOMETER
M
R₂
R₃
V₂
C CAPACITOR
SYNCHRONOUS VIBRATOR
V
V₁
PRI.
SEC.
POWER TRANSFORMER
T₁
LEVER SWITCH
B BATTERY
X
1
2
GROUND UNDER TEST
REFERENCE GROUND
REFERENCE GROUND

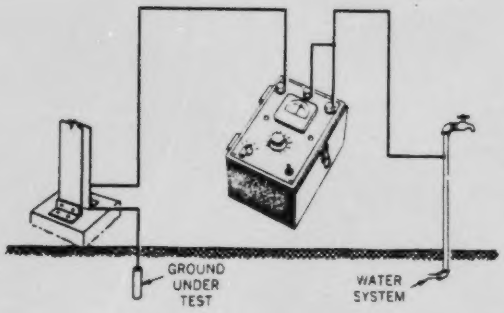
1.55(26D)AX

Figure 4-22.—Basic Vibroground circuit.

1177



26.227X
Figure 4-23.—Vibroground test setup for checking the resistance to earth of a driven transformer ground.



26.228X
Figure 4-24.—Vibroground test setup when there is a well established low resistance reference ground.

Where practicable, electrically continuous metallic buried water piping shall be utilized for grounding electrodes. Artifical grounding electrodes, where required, shall be the sectional type driven ground rods of cone-pointed copper-encased steel or solid copper. Approved copper-alloy clamps shall be brazed to the upper end of ground rods, and ground wires securely attached thereto by means of a bolted connection. Each ground rod shall be die-stamped near the top with the name or trademark of the manufacturer and the length of the rod in feet. Ground rods shall be driven to a depth of not less than 8 feet and shall have diameters sufficient to permit driving to the necessary depth without being damaged. In no case, however, shall they be less than 5/8 inch in diameter.

SERVIVAR ELECTRICAL TESTER

The Servivar Electrical Tester is a multipurpose electrical instrument designed for resistance, and alternating current and voltage measurements. It is a portable, battery-operated unit consisting of the basic indicator instrument (fig. 4-25), an attachable "Snap-Around" probe for measuring a.c. currents (fig. 4-26) and a "Line Splitter" (fig. 4-27).

Only one scale on the instrument is visible to the user at any given time. This eliminates or reduces confusion and erroneous readings so common to multiple scale instruments. The scales are color coded so that the user can quickly recognize whether he is on the a.c. current scale, a.c. volt scale, or the ohm scale.

Special circuitry (not shown) prevents damage to the meter when voltage is applied inadvertently to the instrument when it is on the ohm scale. This is accomplished without the uses of fuses, circuit breakers, or other devices that would have to be replaced or reset.

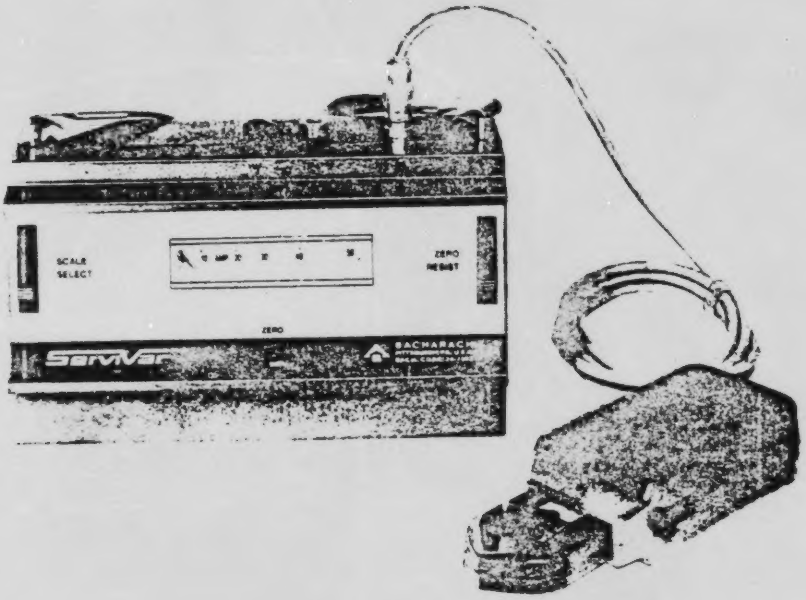
Principles of Operation

The a.c. current to be measured is intercepted from the conductor in which it is flowing by transformer action in the magnetic path that constitutes the "Snap-Around" probe. A pickoff coil located inside the probe and around the magnetic path surrounding the reference conductor supplies voltage to a full-wave bridge through a resistance network. This voltage varies in magnitude in direct proportion to the current that is being measured.

Probe

The probe has been designed to enter into cramped electrical boxes and to snap around an individual conductor in a mass of conductors without the need to reposition the other conductors. It operates as a true "Snap-Around" device that accepts wires up to 0.5 inch outer diameter, rather than a cumbersome scissors type jaw that requires maximum clearance.

The probes are interchangeable with all indicators so that additional probes may be left permanently installed in inaccessible locations.



26.230X

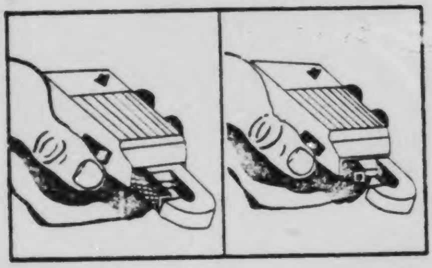
Figure 4-25.—Servivar electrical tester.

The "Snap Around" probe features easy thumb control for quick opening. Retraction is a simple operation. Merely slide thumb knob back and hold at desired clearance. (See fig. 4-26.) To close, release gently, encircling the wire whose current is to be determined.

Line Splitter

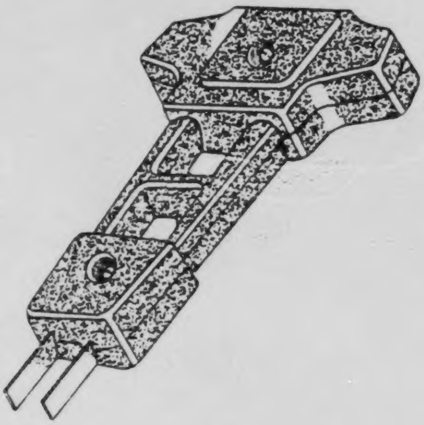
As you know, in measuring a.c. current, it is mandatory that only one conductor be encircled.

It may not be convenient or possible to split the conductors in a two conductor cable so that a current measurement can be made. The line splitter automatically performs this function.



26.231X

Figure 4-26.—Snap-around probe.



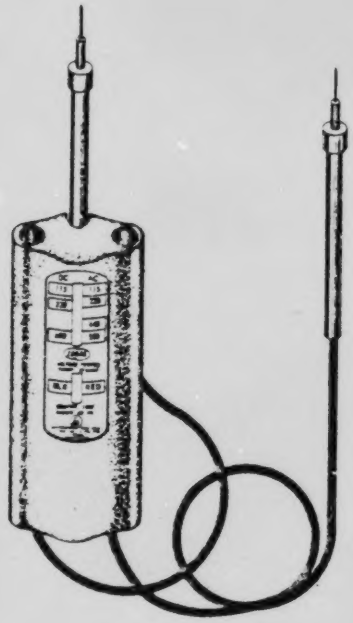
26.232X

Figure 4-27.—Line splitter.

VOLTAGE TESTER

The solenoid type voltage tester is the most frequently used troubleshooting instrument. Every electrician should understand the use and care of this important tool.

The voltage tester (fig. 4-28) is encased in an insulated housing and can be held in the hand when circuit testing. It has two test probes connected to the meter movements by flexible leads. Inside the housing is a solenoid, a coil having a movable core. When the test probes are placed across terminals having a difference of potential (voltage), current flows in the coil. This resultant current flow, which is dependent upon the amount of difference in potential, sets up a magnetic field surrounding the coil. This magnetic field will pull the movable core into the coil. This magnetic pull works against a return spring. The movable core has a pointer attached, which is read against a calibrated scale on the face of the housing. As you gain experience in the art of troubleshooting, you will find the voltage tester an indispensable tool if used properly.



73.32(77B)

Figure 4-28.—Voltage tester.

OTHER DEVICES

There are various other devices used to measure electrical properties and for measuring the speed of electrical equipment. The amount of output of rotating electrical equipment usually varies directly with the speed. Measurement of rotation speed will therefore be one means of measuring and indicating output. Let's examine some instruments using this technique.

PHASE SEQUENCE INDICATORS

The PHASE SEQUENCE INDICATOR is a device used to compare the phase rotation of an incoming alternator operated in parallel with an alternator already on the line; or to determine the phase rotation of equipment being put into use for the first time.

The makeup of a phase sequence indicator is as follows. A tiny three-phase induction motor is equipped with three leads, labeled A, B, and C as shown in figure 4-29. The insulating hoods over the clips are of different colors: red for A, white for B, and blue for C.

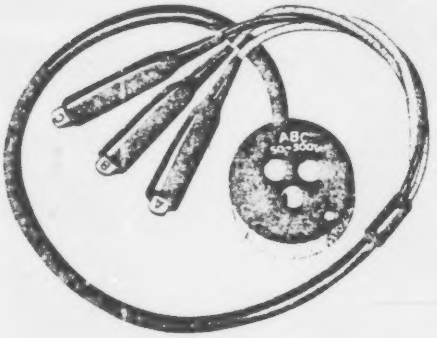
The rotor in the instrument can be observed through the three PORTS as it turns, so that you can note the direction in which it rotates. The rotor can be started by means of a momentary contact switch; it stops again when you release the switch.

Phase sequence is the sequence or order in which the three voltages of a three-phase system appear. When an incoming alternator is cut in with a loadside alternator already in operation, connections must be made so that the phase sequence of the two will be the same.

Figure 4-30 illustrates the procedure for ensuring this with a phase sequence indicator. Connect indicator terminal A to X1, B to Y1, and C to Z1, press the contact switch, and note the direction of rotation of the rotor.

Now move the A terminal to X, the B to Y, and the C to Z, and again press the switch. If the rotor turns in the same direction as before, the phase rotation is the same and the connection can be made X to X1, Y to Y1, and Z to Z1. If the rotor turns in the opposite direction, transpose the connections of any two of the incoming alternator leads before making the connection.

It is not absolutely necessary that A be connected to the left-hand terminal, B to the center terminal, and C to the right-hand terminal. This is a practical method, however, used to avoid the

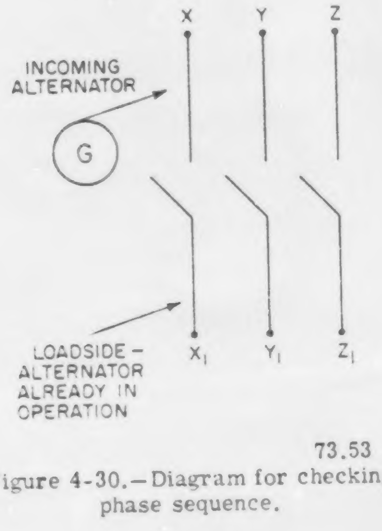


73.52
Figure 4-29.—Phase-sequence meter.

danger of confusing the leads. The important thing is to ensure that the phase sequence indicator that was used on X1 be brought down to X, the one used on Y1 to Y, and the one used on Z1 to Z. Reversing any two of the leads will reverse the direction of rotation of the rotor.

SYNCHROSCOPES

The SYNCHROSCOPE is essentially a power factor meter connected so as to measure phase relation between generator voltage and bus bar voltage when an additional generator is being put on the line.



73.53
Figure 4-30.—Diagram for checking phase sequence.

Later in this manual you will find that, when two alternators are to be operated in parallel, phase sequence, voltage, and frequency must be the same for the incoming alternator and the energized bus bars. The generator frequency must be practically constant, and the generator and bus bar voltage in phase.

Bringing this condition about is called "synchronizing" the alternator. This is commonly done by an arrangement of lamps described in a later chapter. However, the use of a synchroscope is more accurate.

With a synchroscope you determine (1) if the frequency of the alternators is the same or different, (2) if frequency is constant for an appreciable time, and (3) whether or not bus bar voltages of both generators are in phase—that is, whether they reach maximum value at the same time.

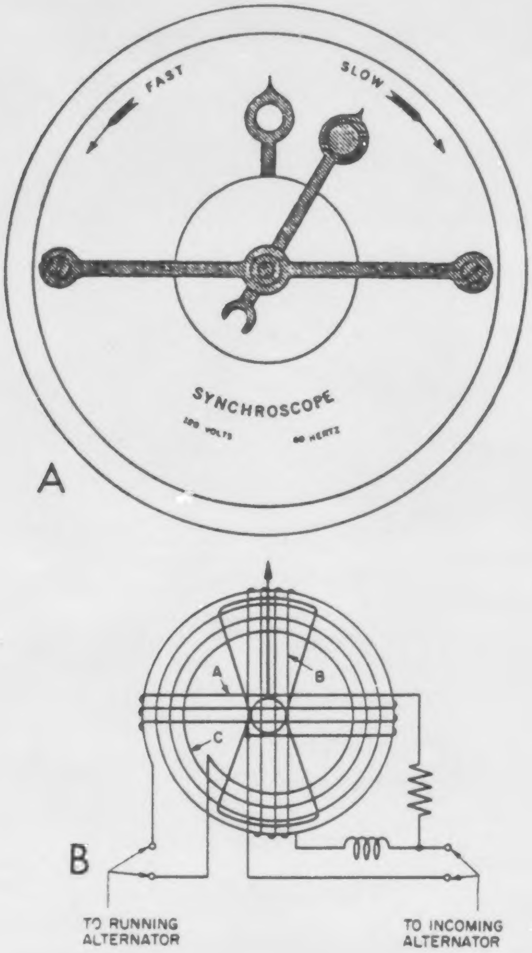
Figure 4-31A shows the dial of a synchroscope, figure 4-31B a wiring diagram of the instrument. Coils A and B are connected to the incoming generator through a potential transformer. Coil C is connected to the bus line. One pointer holds a fixed position at the top of the dial as shown in figure 4-31. The moving element is attached to the second, movable pointer. If the frequencies are the same, this pointer takes a fixed position. With any slight variation in frequency, however, it will begin to travel—toward SLOW if the incoming generator is slow, toward FAST if it is fast. The amount of difference in frequency is indicated by the speed of travel.

You synchronize by adjusting the speed of the incoming generator, in accordance with what you read, until you bring the movable pointer even with the stationary pointer.

REVOLUTION COUNTER OR TACHOMETER

To determine the speed of a revolving shaft you use a REVOLUTION COUNTER or TACHOMETER. A tachometer gives a direct reading on the dial of the number of revolutions per minute (r.p.m.) the shaft is turning. On some types no timing is necessary, and any variations in shaft speed are reflected in the movement of the pointer. On some equipment a tachometer can be used in place of a frequency meter.

There are several types of tachometers or indicators that can be used for indicating shaft speeds from remote positions, such as:



73.54:.55

Figure 4-31.—Dial face and wiring diagram of a synchroscope.

1. A d.c. generator type, with a voltmeter indicator.
2. An a.c. generator type, containing a transformer and a rectifier-type a.c. voltmeter.
3. A three-phase a.c. generator type, with an indicator using a synchronous motor operating a magnetic-drag assembly.

The first two types are usually switchboard-mounted, although the d.c. type with voltmeter indicator can be a portable instrument. The third type is attached to the rotor of the synchronous motor. The rotating magnets produce a torque proportionate to shaft speed to drive the pointer.

For a switchboard-mounted instrument the operating principle is somewhat different. In the d.c. generator type, the generator is driven from the shaft whose rpm is to be measured. Because generator output voltage is proportional to speed, the voltmeter is simply calibrated to revolutions per minute instead of volts.

The a.c. generator type is frequency-sensitive rather than voltage-sensitive. The transformer output is proportional to the frequency of the applied voltage, but the frequency is also proportional to the speed of the generator.

Some types of a.c. tachometer equipment, used principally to measure low speeds, may consist of the a.c. generator and the rectifier-type voltmeter. Over the rated speed range, voltage output is directly proportional to speed, and the instrument dial may be calibrated in any units related to speed, such as revolutions per minute or feet per minute.

COMMUNICATIONS TEST EQUIPMENT

Various testing instruments are used to check out communication circuits and equipment. In this portion of the chapter, we will discuss applications of the portable WHEATSTONE BRIDGE, the CABLE REPAIRMAN's test set, telephone test set AN/PTM-5, and a cable tester.

WHEATSTONE BRIDGE

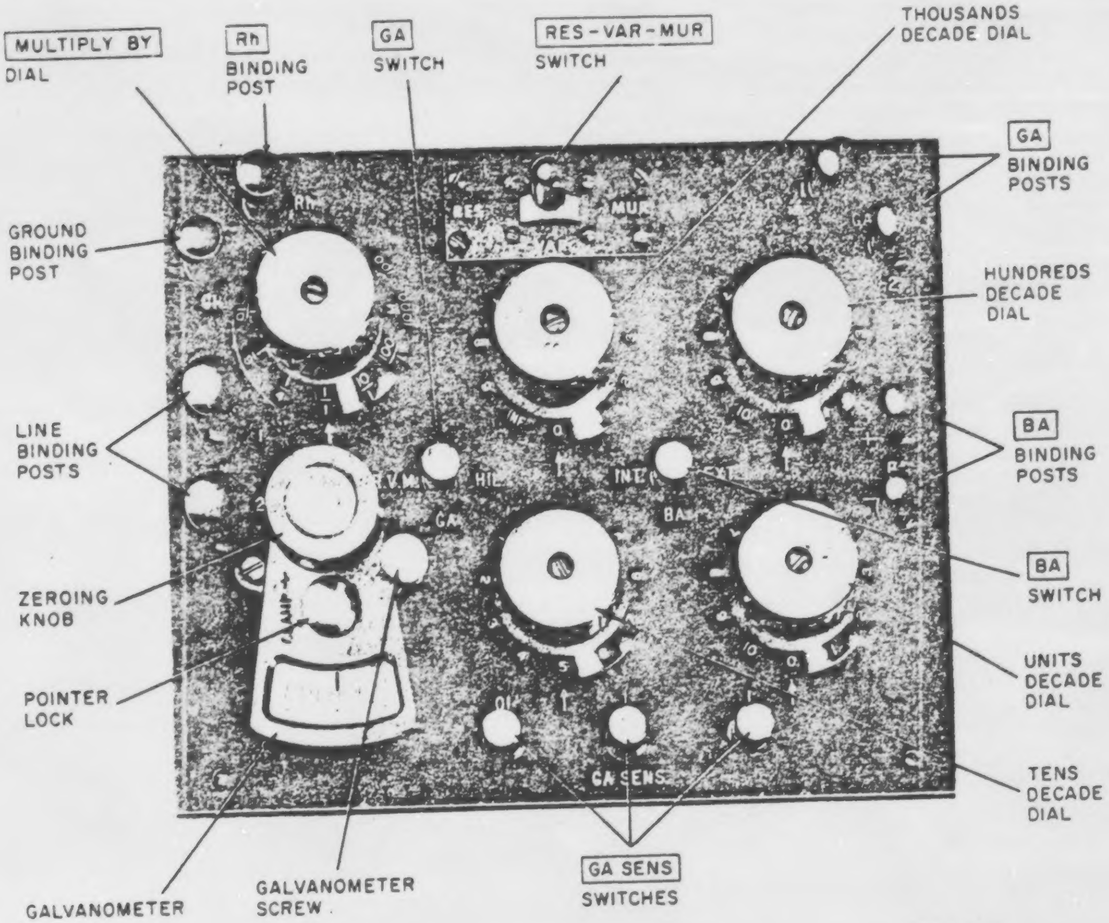
The Wheatstone bridge (fig. 4-32) may be used to measure the resistance of a pair of wires in a telephone cable, or to locate the distance to a fault (ground) in the cable by either of two methods, the Varley (Var) loop test or the Murray (Mur) loop test.

Preoperational Test

Place the instrument on a level surface as near as possible to the test point and follow the preoperational test procedure indicated in the manufacturer's instruction manual.

Measurement of Unknown Resistances

Once the instrument accuracy has been verified, and the resistance of a loop or other resistance is to be determined, measurement can be easily made by referring to table 4-1 and setting the MULTIPLY BY dial to that setting closest to the estimated value of the unknown resistance.


MULTIPLY BY
DIAL
Rh
BINDING POST
GA
SWITCH
RES-VAR-MUR
SWITCH
THOUSANDS DECADE DIAL
GA
BINDING POSTS
GROUND BINDING POST
HUNDREDS DECADE DIAL
LINE BINDING POSTS
BA
BINDING POSTS
BA
SWITCH
ZEROING KNOB
UNITS DECADE DIAL
POINTER LOCK
TENS DECADE DIAL
GALVANOMETER
GALVANOMETER SCREW
GA SENS
SWITCHES

26.43.2

Figure 4-32.—Wheatstone Bridge operating controls.

If the resistance of a loop is to be determined, disconnect all equipment from the near end of the loop and connect one wire of the loop to the binding post X_1 and the other wire to line binding post X_2 (fig. 4-33). Be sure that the wires connected to the test set are clean and firmly secured to the binding posts. Have all equipment disconnected from the far end of the loop and a short placed across the circuit at that end.

If the resistance of an electrical component is to be measured, connect the component across line binding posts X_1 and X_2.

The bridge is balanced and the test procedure complete when the GA SENS switches (fig. 4-32) are pressed in proper sequence and the pointer on the galvanometer does not move in either direction. Resistance is determined by summing up the decade dial settings and multiplying that result by the setting of the MULTIPLY BY dial.

REGULAR VARLEY LOOP TEST

The regular Varley loop test (fig. 4-34) is used to locate a ground in a high-resistance loop when the unbalance (difference in resistance between the faulty and good wires) does not exceed 1 ohm. The regular Varley method

Table 4-1.—MULTIPLY BY dial setting when measuring resistance.

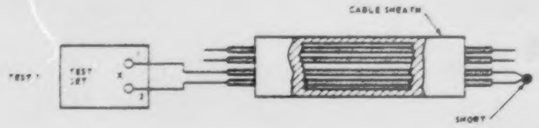
ESTIMATED RESISTANCE (ohms)	MULTIPLY BY dial setting
Below 10	$\frac{1}{1000}$
10 to 1000	$\frac{1}{100}$
100 to 1000	$\frac{1}{10}$
Used in Varley tests	$\frac{1}{9}$
Used in Varley tests	$\frac{1}{4}$
1000 to 10,000	$\frac{1}{1}$
10,000 to 100,000	$\frac{10}{1}$
100,000 to 1,000,000	$\frac{100}{1}$

73.340

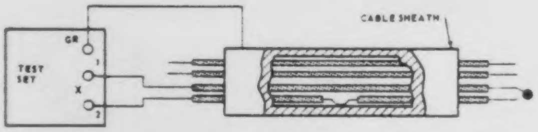
requires the use of one good wire between the test point and the far end of the circuit.

Location of the ground can be achieved using the following formulae, all of which are derived from the original Wheatstone Bridge. (Refer to the Regular Varley Loop test circuit (fig. 4-35).)

(1) Basic equation:



26.44
Figure 4-33.—Connection for measurement of loop resistance.



26.45
Figure 4-34.—Connections for ground location, regular Varley and Murray loop tests.

(2) The equation used to determine the resistance from test point to fault (X_a) equals:

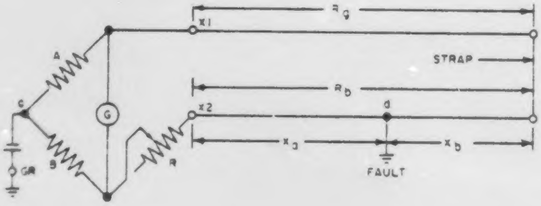
$$X_a = \frac{rB - AR}{A + B}$$

where r equals $R_g + R_b$ (loop resistance)

(3) The equation used to determine resistance from far end to fault (X_b) equals:

$$X_b = \frac{A(R + R_b) - BR_g}{A + B}$$

where A = numerator of position of MULTIPLY BY dial,
B = denominator of position of MULTIPLY BY dial,
r = loop resistance as calculated in previous paragraph, Measurement of Unknown Resistance,
R = decade dial reading after balancing,
R_g = resistance of good wire from test point to far end,
R_b = resistance of faulty wire from test point to far end.



26.46.1
Figure 4-35.—Regular Varley loop test circuit, simplified schematic diagram.

THREE VARLEY TEST

This test has a definite advantage, especially for central desk testing, over other types of tests in that the resistance of the test cords and the conductors themselves neither need to be known nor allowed for in the calculations. Its chief drawback lies in the fact that a good pair (two conductors of any resistance) are needed in addition to the faulty conductor and ground.

NOTE: Lead wires and conductors may be of unequal resistance, because this method balances out their resistances.

The test derives its name from the Varley Loop and from the fact that three such tests must be made. However, each is simple as shown in the diagrams and any tester who can perform the simple Varley should achieve accurate results here. (See fig. 4-36 (a), (b), and (c).) The three tests made are known as "Varley 1", "Varley 2" and "Varley 3", using the connections as shown in figure 4-36 (a), (b), and (c).

Calling the rheostat readings at balance R1, R2, and R3 respectively, the basic equations are:

$$\frac{A}{B} = \frac{R_g}{R_1 + R_b} = \frac{R_g + X_b}{R_2 + X_a} = \frac{R_g + R_b}{R_3}$$

From which may be obtained the working equations:

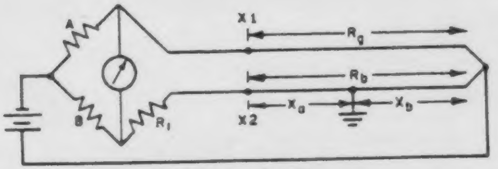
$X_a = \frac{A}{A + B} \times (R_3 - R_2)$ used to determine the resistance (X_a) between the test point and the fault.

$X_b = \frac{A}{A + B} \times (R_2 - R_1)$ used to determine the resistance (X_b) between the fault.

$R_b = X_a + X_b = \frac{A}{A + B} \times (R_3 - R_1)$ to determine the resistance (R_b) of the full length of the faulty wire.

These symbols are identified in equation 3 under Regular Varley Loop Test.

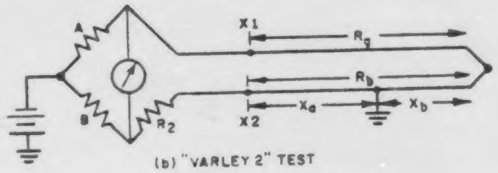
In using the three (3) Varley Test, MULTIPLY BY dial ranges 1/1, 1/4, or 1/9 are recommended. Once the range has been selected,



(a) "VARLEY 1" TEST

VARLEY 1 TEST BASIC EQUATION:

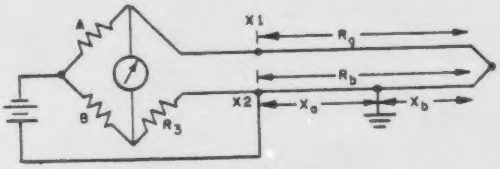
$$\frac{A}{B} = \frac{R_g}{R_b + R_1}$$



(b) "VARLEY 2" TEST

VARLEY 2 TEST BASIC EQUATION:

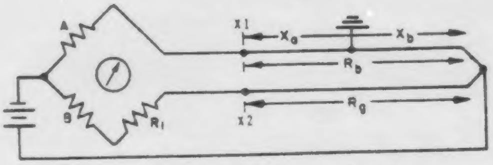
$$\frac{A}{B} = \frac{R_g + X_b}{X_a + R_2}$$



(c) "VARLEY 3" TEST

VARLEY 3 TEST BASIC EQUATION:

$$\frac{A}{B} = \frac{R_g + R_b}{R_3}$$



(d) MODIFIED "VARLEY 1" TEST

NOTE: CONNECTIONS OF POSITIVE PORTION OF BATTERY DISTINGUISH BETWEEN THE THREE VARLEY TESTS.

26.46.2

Figure 4-36.—Simplified schematics and basic equations for "Three Varley Tests".

it must be used on all three tests to produce accurate results.

To determine the resistance to the fault to tenths of an ohm, the ratio A/B must be approximately 1/10. The ratio 1/9 and 1/4 are convenient in some models, because their working equations reduce, respectively, to the forms:

$$X_b = \frac{R_2 - R_1}{10},\ X_a = \frac{R_3 - R_2}{10},\ \text{and}\ R_b = \frac{R_3 - R_1}{10}$$

$$X_b = \frac{R_2 - R_1}{5},\ X_a = \frac{R_3 - R_2}{5},\ \text{and}\ R_b = \frac{R_3 - R_1}{5}$$

When the total resistance of the loop is more than about 1000 or 1100 ohms, it is impossible to balance the bridge when using the 1/10 or 1/9 MULTIPLY BY dial setting. It may then be necessary to use A/B = 1. Then, if the good wire is of lower resistance than the faulty wire the bridge cannot be balanced in the "Varley 1" test. The good and bad wires, with their leads, must be interchanged as in figure 4-36 (d), while making the "Varley 1" test only. The working equations under these conditions are:

$$X_b = \frac{R_2 + R_1}{2},\ X_a = \frac{R_3 - R_2}{2}\ \text{and}\ R_b = \frac{R_3 - R_1}{2}$$

To avoid the need for interchanging the good and bad conductors in the "Varley 1" test, a small resistor may be connected between the test set and the good conductor. It is used during all three tests. Any reasonable value of resistance may be used which is large enough to make the resistance of the good conductor higher than that of the bad one. Its value need not be known since it is automatically eliminated by this method of test.

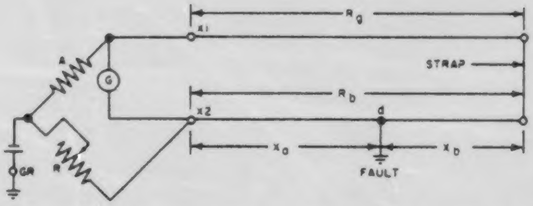
MURRAY LOOP TEST FOR LOCATING A GROUND

To use the Murray loop test for locating a ground, a good wire should be available (fig. 4-34) in addition to the grounded wire. A simplified schematic is shown in figure 4-37. Remove all equipment from both ends of the circuit and locate the fault using the manufacturer's instructions and either of the following methods:

(a) Direct computation, for solving d_a, the distance from the test point to the fault, when total mileage of loop is known.

$$d_a = \frac{R \times L}{R + A},$$

where R equals the decade dial sum, L equals the total loop distance in miles and A equals the MULTIPLY BY dial reading (usually set at M 10, M 100, or M 1000 for Murray Loop readings).



26.46.3

Figure 4-37.—Regular Murray loop test for locating ground.

(b) Resistance-distance method is used after the resistance X_a (from the test point to the fault) has been determined using the formula

$$X_a = \frac{R \times r}{R + A},$$

where R = total decade dial reading.
r = total loop resistance of the faulty circuit
A = numerator of the position of MULTIPLY BY dial.

The result obtained from the above calculation is then substituted in

$$d_a = \frac{X_a}{1/2 \text{ resistance per loop mile}},$$

and should agree with the result calculated by the direct computation method.

CABLE REPAIRMAN'S TEST SET

The cable repairman's test set, I-51 (fig. 4-38) is used to pinpoint the location of cable faults after the approximate location of the fault has been obtained by the use of the Wheatstone bridge or some other method. The test set can be used to locate shorts, grounds, crosses, split pairs, wet spots, and similar troubles in a cable. IT CANNOT BE USED TO LOCATE OPEN CIRCUITS.

The test set includes a tone unit, an exploring coil equipped with three jacks, and a telephone

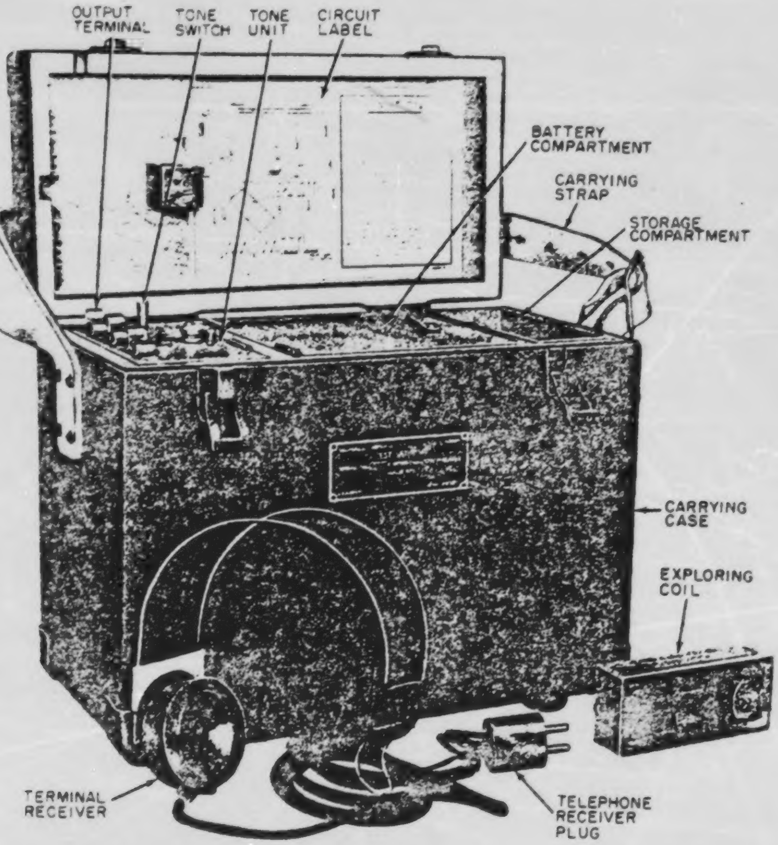

OUTPUT TERMINAL
TONE SWITCH
TONE UNIT
CIRCUIT LABEL
BATTERY COMPARTMENT
CARRYING STRAP
STORAGE COMPARTMENT
CARRYING CASE
EXPLORING COIL
TERMINAL RECEIVER
TELEPHONE RECEIVER PLUG
26.47

Figure 4-38.—Cable repairman's test set I-51.

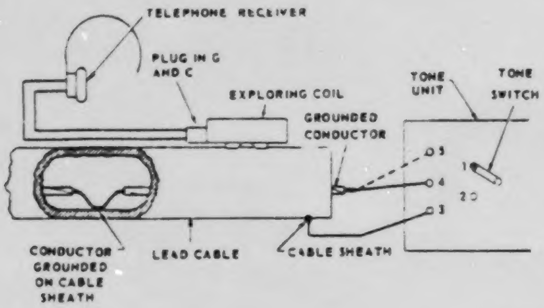
receiver equipped with a cord and plug for connection to the exploring coil packs. The tone unit has a switch for selecting steady or interrupted tone and a set of terminals for connecting the tone unit to the faulty conductors. These units are housed in a carrying case which is provided with an adjustable carrying strap. The inside of the carrying case is divided into three compartments: one for the tone unit, one for the batteries, and one for storing the exploring coil and the receiver. In addition to the components supplied with the test set, it is necessary to have 4 (BA-23) batteries to furnish the required 6 volts, two alligator clips and approximately 10 feet of two-conductor cable required to assemble the test cord.

Operating Procedures

Before you use the test set study your instruction manual. Obtain information from the central office personnel on the type of cable fault, the resistance of the faulty conductors, and the approximate location of the fault.

Location of Grounds

Grounds are located by making connections and setting controls as shown in figs. 4-39 and


TELEPHONE RECEIVER
PLUG IN G AND C
EXPLORING COIL
TONE UNIT
TONE SWITCH
GROUNDED CONDUCTOR
5
4
3
1
2
CONDUCTOR GROUNDED ON CABLE SHEATH
LEAD CABLE
CABLE SHEATH

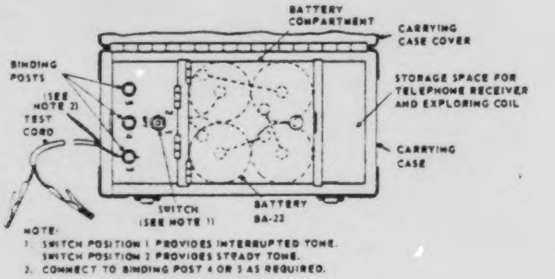
26.49
Figure 4-39.—Connections for locating ground.

4-40. Note that regardless of how much resistance exists between the point where the tone is applied and the probable location of the fault, binding post 3 is always used. Use binding posts 3 and 4 for cable faults having a resistance of less than 100 ohms between those points and binding posts 3 and 5 for those 100 ohms or more.

At the approximate location of the fault, place the telephone receiver in position over one ear and hold the exploring coil parallel to the cable as shown in figure 4-41. Be sure that the telephone receiver plug is inserted into the G and C jacks of the exploring coil (Fig. 4-39).

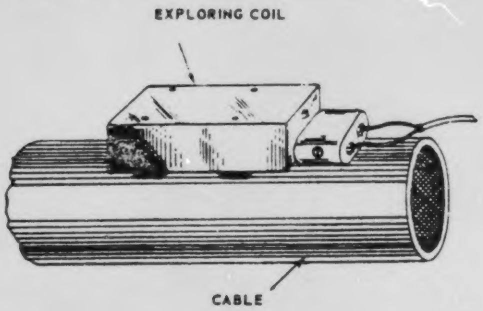
While listening with the receiver, move the exploring coil along the cable toward the fault until the tone disappears or the volume of the tone is markedly decreased. This should be the exact location of the fault.

NOTE: In high resistance faults, the tone will not disappear when the fault is passed because of a carryover effect of the line capacitance. In some cases, the change in volume is so slight that an absolute location of the fault is uncertain. In such cases, place a chalk mark at the approximate location, then transfer the test set to the other end of the cable, and repeat the steps given above.


BATTERY COMPARTMENT
CARRYING CASE COVER
BINDING POSTS
(SEE NOTE 2)
TEST CORD
STORAGE SPACE FOR TELEPHONE RECEIVER AND EXPLORING COIL
CARRYING CASE
SWITCH (SEE NOTE 1)
BATTERY BA-23

NOTE:
1. SWITCH POSITION 1 PROVIDES INTERRUPTED TONE. SWITCH POSITION 2 PROVIDES STEADY TONE.
2. CONNECT TO BINDING POST 4 OR 5 AS REQUIRED.

26.48
Figure 4-40.—Test set, top view with cover open.


EXPLORING COIL
CABLE

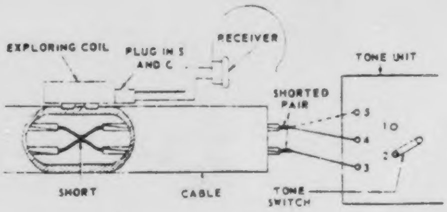
26.50
Figure 4-41.—Position of exploring coil for locating grounds, shorts, or split pairs.

Location of Shorts

An insulation breakdown between the two conductors of a pair which permits the two wires to touch each other will cause a short circuit. A short may also occur if moisture enters the cable sheath and reduces the insulation resistance between the two wires of the pair to the point where the conductors cannot be used efficiently.

In locating shorts with the cable repairman's test set make connections as shown in fig. 4-42.

At the approximate location of the fault, place the telephone receiver plug in position over one ear and hold the exploring coil parallel to the cable as shown in figure 4-41 and 4-42. Be sure that the telephone receiver plug is


EXPLORING COIL
PLUG IN S AND C
RECEIVER
TONE UNIT
SHORTED PAIR
5
1
4
2
3
SHORT
CABLE
TONE SWITCH

26.51
Figure 4-42.—Connections for locating shorts.

inserted in S and C jacks of the exploring coil. (See fig. 4-42.)

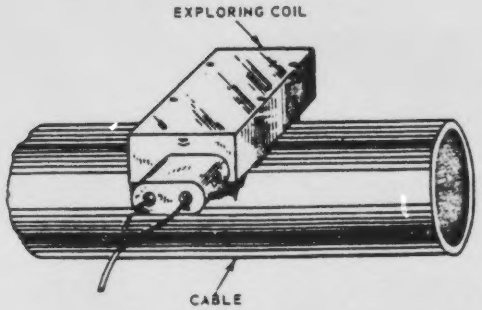
While listening with the receiver, move the exploring coil along the cable toward the fault. The tone will decrease and increase in volume as the coil is moved along the cable. This is called the short-circuited effect. When the coil is moved over the fault, the tone will decrease considerably in volume or disappear entirely.

NOTE: If uncertain of the exact location, transfer the test set to the other end of the cable and repeat the steps given above.

Location of Crosses

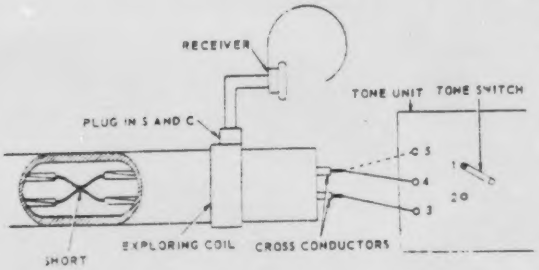
A cross is essentially the same as a short except that the contact is between conductors from two different pairs.

To locate crossed wires make connections and hold exploring cables as shown in figures 4-43 and 4-44.



26.52

Figure 4-43.—Position of exploring coil for locating crosses and wet spots.



26.53

Figure 4-44.—Connections for locating crossed wires.

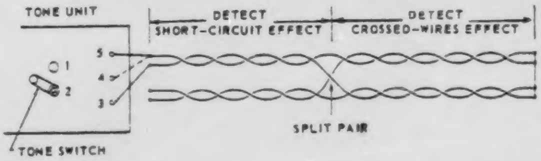
While listening with the receiver, move the exploring coil along the cable toward the fault until the tone fades out or is reduced considerably in volume. The steady volume tone heard while tracing crossed wires is known as the crossed-wires effect.

NOTE: If uncertain of the exact location of the fault, place a chalk mark at the approximate location, then transfer the test set to the other end of the cable and repeat the steps given above.

Location of Split Pairs

A split pair is caused by splicing error in which one wire of a pair is connected to one wire of another pair.

Make connections as shown in fig. 4-45 and hold the exploring coil parallel to the cable as shown in fig. 4-41 to locate a split pair.



26.54

Figure 4-45.—Connections for locating split pairs.

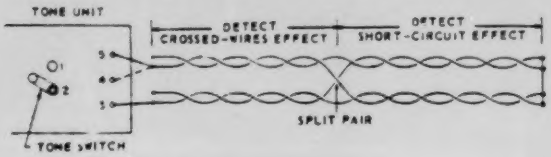
While listening with the receiver, move the exploring coil along the cable toward the fault. The tone will increase and decrease in volume (short-circuit effect) up to the location of the fault and, thereafter, will be steady in volume (crossed-wires effect).

To ensure accurate location of the fault, mark the cable at the location found above, and then use the alternative method of locating split pairs described below as a check.

Alternative Method of Locating Split Pairs

Connect the output terminals of the test set to one wire of one of the split pair (strapped at the far end of the cable) and to one wire of the other pair as shown in figure 4-46.

While listening with the receiver, move the exploring coil along the cable toward the fault. The tone will be steady in volume (crossed-wire



26.55

Figure 4-46.—Alternative connections for locating split pairs.

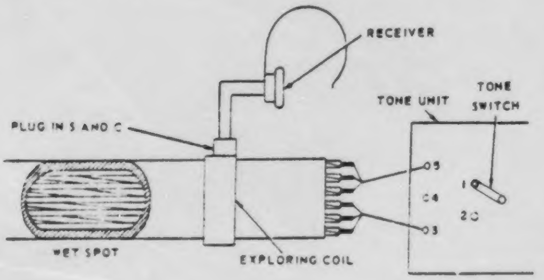
effect) until the fault is reached; thereafter the tone will increase and decrease in volume (short-circuit effect).

NOTE: It is possible to connect the test set in such a manner that the short-circuit effect will not be detected. If this happens, reconnect one of the test leads to the other wire of the pair to which it is connected. The short-circuit effect now should be heard as described above.

Location of Wet Spots

Normally a wet spot in a cable is caused by an opening in the cable sheath. In aerial cables, this opening can be caused by squirrels chewing on the cable sheath or by tree limbs, cable rings, or cable lashing wire rubbing against the sheath. In underground cables, an opening in the sheath normally is caused by soil erosion or electrolysis. When an opening appears in the sheath, moisture eventually enters the cable and forms a combination of grounds, short circuits, and crosses.

In locating wet spots with the test set, connect the output terminals to each group of strapped wires (fig. 4-47) and set the tone switch to position 1.



26.56

Figure 4-47.—Connections for locating wet spots.

At the approximate location of the fault, place the telephone receiver in position over one ear and hold the exploring coil at right angles to the cable as shown in figure 4-43. Be sure that the telephone receiver plug is inserted into the S and C jacks of the exploring coil.

While listening with the receiver, move the exploring coil along the cable toward the fault. A steady tone will be heard up to the location of the fault and, thereafter, the tone will either decrease considerably in volume or disappear entirely.

To ensure accurate location of the fault, mark the cable at the location found above, and use the alternative method of locating wet spots described below as a check.

Alternative Methods for Locating Wet Spots

Strap together one group of wires which have a low resistance to ground.

Connect one output terminal of the test set to the cable sheath and the other to the strapped group of wires. Leave the tone switch set to position 1.

At the approximate location of the fault, place the telephone receiver in position over one ear and hold the exploring coil parallel to the cable as shown in figure 4-41. Be sure that the telephone receiver plug is inserted into the G and C jacks of the exploring coil.

While listening with the receiver, move the exploring coil along the cable toward the fault until the tone disappears or the volume of the tone is markedly decreased, which indicates the exact location of the fault.

Location of Buried Cable

It sometimes becomes necessary to trace the unknown path of a buried cable. When there is trouble in a buried cable, much excavation may be avoided if the exact location of the cable can be determined. Only the tracing methods directly applicable to buried cable are discussed in this section.

In conjunction with the cable repairman's test set I-51, the following items of equipment are required for tracing buried cable.

Amplifier---	BC-1388
Coil--------	24- or 26-inch diameter exploring induction coil
Receivers--	Two No. 716-D receivers equipped with a WECo R2CF cord and a WECo 11a headband
Rods-------	Two ground rods, GP-26

The exploring coil is not available as a standard item, but can be constructed locally as follows:

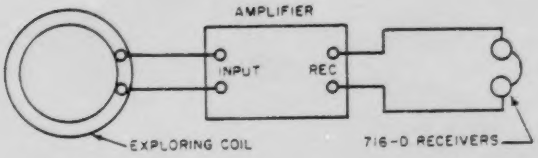
Wind approximately 300 turns of No. 24-gage double cotton-covered copper wire on a light circular frame with a diameter of 24 or 26 inches to make the coil. Then bring the two ends of the windings about 1/2 inch apart from the side of the coil. Wrap a layer of rubber tape and then a layer of friction tape in the reverse direction over the wound wire, bringing the ends of the wire out of the coil between the layer of the tapes. Terminate the ends of the winding by soldering them to binding posts mounted in a small insulating strip. A piece of hard rubber 3/16 inch by 3/4 inch by 2 1/2 inches will serve satisfactorily as the strip. Apply two coats of asphalt paint to the entire coil. Then fasten the terminal strip to the inside of the completed coil.

In an emergency any fine-gage insulated wire wound into a coil about 2 feet in diameter can be used in place of the coil described above.

Under some conditions, the pickup of the exploring coil will be sufficient to give a suitable signal when connected directly to the No. 716-D receivers. If the signal is not strong enough to permit tracing, an amplifier, such as the BC-1388, is connected to the listening circuit. Figure 4-48 shows a schematic view of the exploring coil.

Stray Current Method of Tracing Conductor

In locating and tracing the path of a buried cable or a conductor which is not readily accessible, it is generally advisable first to attempt to make a location by the stray current method with the coil held in a horizontal position. Walk across the approximate path of the conductor to determine whether there is sufficient stray current flowing to give an audible signal or tone in the receivers. If there is, the tone volume will rise gradually to a maximum as the conductor is approached, suddenly fall to a low value when the coil is directly over the conductor, rise again to previous maximum as the conductor is passed, and then decrease slowly. If the exploring is done in the proximity of a power line, most of the tone heard may be the result of induction from the line.



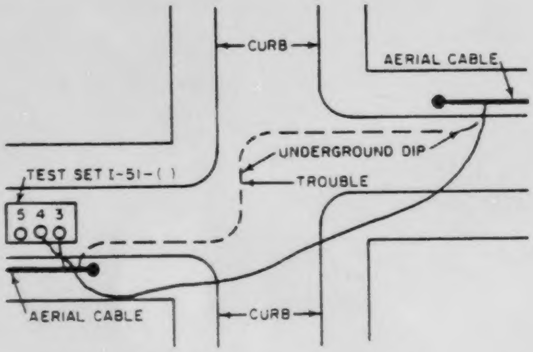
26.57

Figure 4-48.—Exploring coil for tracing buried cable.

Tracing Conductor by Use of Test Set I-51

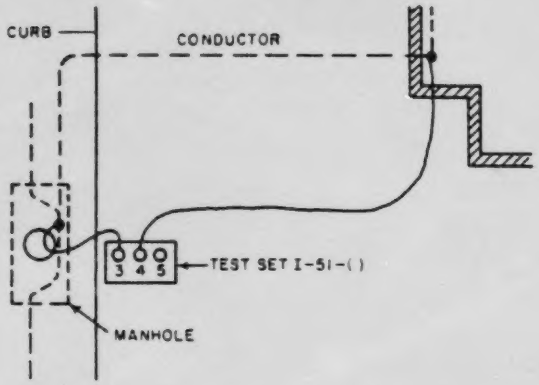
If there is too much disturbance from the power line, or if the tone volume is inadequate, the stray current method will not be effective. Under such conditions the locating and tracing of a cable can generally be facilitated by using Test Set I-51 as a source of tracing current. The test set is placed as far as possible from the conductor at the point of tracing. The set may then be connected in any one of three ways, depending on the distance to be covered and the accessibility of the conductor to be located. Regardless of the method of construction, intermittent tone should be used in the set.

When the conductor to be traced is relatively short and is accessible at two points, as shown in figures 4-49 and 4-50 (one on each side of the area in question), it is advisable to connect the set directly. The connection is made with insulated wires which are attached to terminals 3 and 4 of the set, and are placed on the ground in such a way that they will not parallel the



26.58

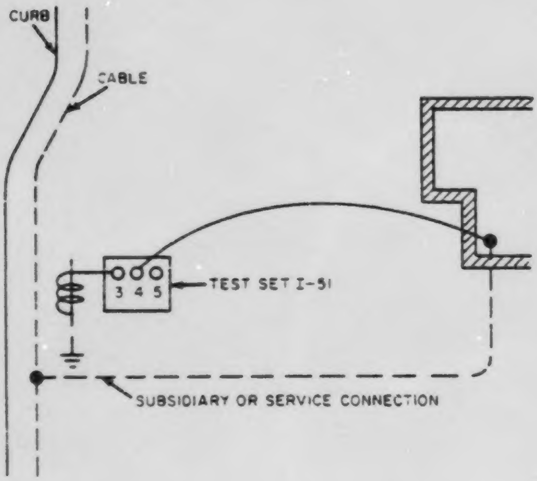
Figure 4-49.—Tracing buried cable conductor with test set I-51, underground dip.



26.59
Figure 4-50.—Tracing cable conductor in underground subsidiary with test set I-51.

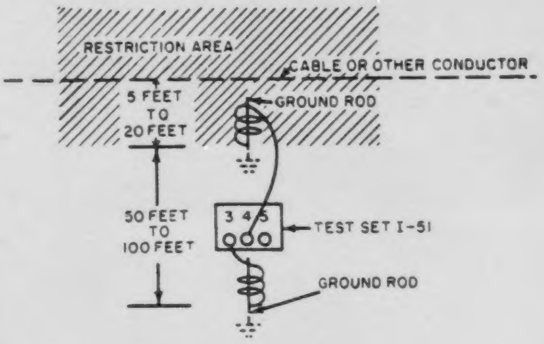
conductor in the area where the location is made. Intermittent tone should be used.

When the conductor to be traced is accessible at one point and the approximate location is known at another point, the tracing current can be applied as illustrated in figure 4-51. Install the ground rod 5 to 20 feet from the cable. Connect the set to the conductor and rod as described above, except that a number 3 bridging connector may be used to attach the lead to the rod.



26.60
Figure 4-51.—Tracing accessible conductor with test set I-51 and one ground rod.

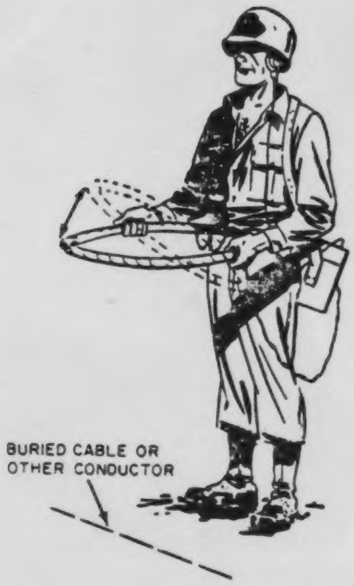
If the conductor to be traced is not accessible and the approximate location is known, install one ground rod close to the conductor (5 to 20 feet), and another ground about 50 feet from the first ground rod and in a line approximately at right angles to the conductor (fig. 4-52). If the approximate location of the conductor is not known, the separation between the rods should be about 100 feet. If a power line is in the vicinity of the conductor, place the rods on the power-line side of the conductor. Drive the rods approximately 2-1/2 feet into the earth; but where the soil is loosely packed or contains many small stones, drive the rods deeper, or move them to another location where the soil conditions are more favorable. If the separation between rods is not over 50 feet, make location tests at a point not less than 100 feet from the rods. Within this area a strong tone will be heard, but the location will not be reliable. Where the separation is more than 50 feet, the restricted area extends about 200 feet from the conductors.



26.61
Figure 4-52.—Tracing inaccessible conductor with test set I-51 and two ground rods.

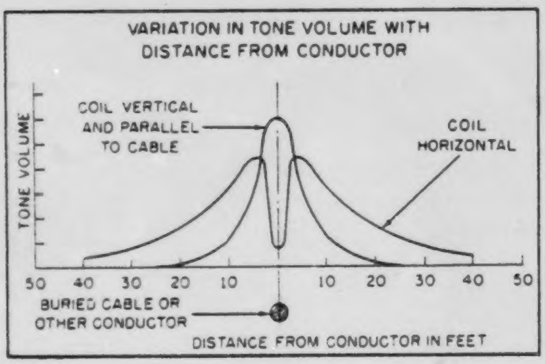
Locating Conductors

To locate conductors, stand at a point that is believed to be near the cable or conductor (on the side away from any power line, if there is one near by). Hold the exploring coil in a horizontal position and rock it slowly around a horizontal axis which is considered parallel to the conductor, as shown in figure 4-53, until a



26.62
Figure 4-53.—Getting general location of buried cable.

tone is heard. If no tone is heard, move to other positions in the general vicinity of the suspected location of the cable, until a tone is heard. This verifies the fact that you are in within 40 feet (approximately) of the cable. (See fig. 4-54.)



26.233
Figure 4-54.—Tone volume versus position of coil and distance from cable.

After this general location of the conductor has been determined, the following procedure is used to determine the exact location. Starting at the point where the tone is first heard and with the coil held in a horizontal position, the volume of the tone heard will rise gradually to a maximum as the conductor is approached (fig. 4-54), suddenly fall to a low value when the coil is directly over the buried conductor, rise again to the previous maximum as the conductor is passed, and then decrease slowly.

A further check on the direction of the cable run can then be made by holding the exploring coil in a vertical position and then rotating the coil around its vertical axis. When the tone is at a minimum, the plane of the coil is perpendicular to the conductor. When the tone is at a maximum, the plane of the coil is parallel to the conductor.

A check may be made by holding the coil in a vertical position, with the plane of the coil parallel to the conductor, and again walk across the conductor. The tone volume will rise as the conductor is approached, reach a maximum directly over the conductor, and then decrease as the conductor is passed (fig. 4-54).

TELEPHONE TEST SET AN/PTM-5

Telephone test set AN/PTM-5 (fig. 4-55) is a portable, lightweight, battery operated cable splicer's test set that will detect and amplify weak tone signals. The test set is used to identify single leads or pairs in a cable without breaking the individual conductor insulation. It can be used with either a test probe or an exploring coil.

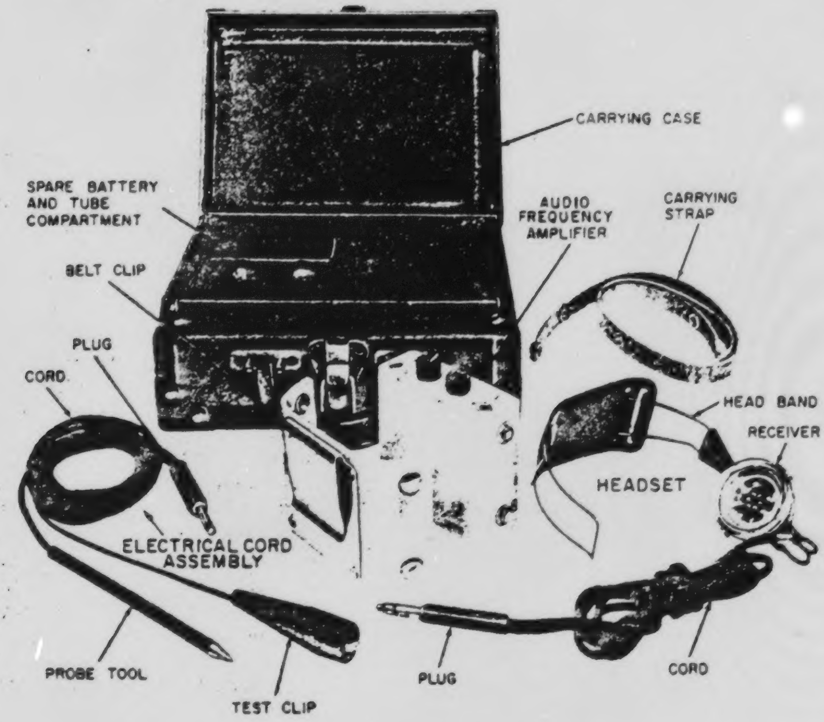
The instrument consists of an AUDIOFREQUENCY AMPLIFIER, ELECTRICAL ASSEMBLY, HEADSET, belt clip, carrying strap, case, and associated spare parts (fig. 4-55).

Additional Equipment Required

The following equipment is not supplied as part of the AN/PTM-5, but is required for all types of operation of the test set.

(1) One battery BA-261/U (22-1/2 volts).
(2) Two batteries BA-58 or one battery BA-272/U (1-1/2 volts).
(3) An audio oscillator with an output frequency of approximately 500 hertz is required as a tone source.

When the test is used with an exploring coil (such as Sig C stock no. 3F4316.2), the following


CARRYING CASE
SPARE BATTERY AND TUBE COMPARTMENT
AUDIO FREQUENCY AMPLIFIER
CARRYING STRAP
BELT CLIP
PLUG
CORD
HEAD BAND
RECEIVER
HEADSET
ELECTRICAL CORD ASSEMBLY
PROBE TOOL
TEST CLIP
PLUG
CORD

73.284

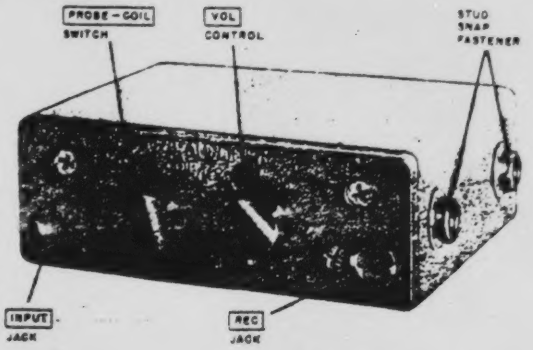
Figure 4-55.—Telephone test set AN/PTM-5.

additional equipment is required to connect the exploring coil to the test set.

(1) Cord (Sig C stock No. 3E8000-72.2).
(2) Plug (Federal stock No. 5935-192-4774).

Audiofrequency Amplifier AM-984/U

The AM-984/U (amplifier) is contained in a gray metal box. Operating controls (fig. 4-56) are mounted on the plastic front panel. A belt clip can be secured to the amplifier case by snap fasteners on each side of the amplifier case. The operating controls and jacks (fig. 4-56) perform the following functions. The INPUT jack connects a probe or exploring coil to the input of the amplifier. The REC (receive) jack connects the amplifier output to the headset. The PROBE-COIL switch, when turned to the PROBE position, connects the INPUT jack to the amplifier through a high impedance network. When it is in the COIL position, the INPUT jack is connected to the amplifier through a low impedance network. The VOL control adjusts the volume of


PROBE-COIL SWITCH
VOL CONTROL
STUD SNAP FASTENER
INPUT JACK
REC JACK

73.285

Figure 4-56.—Amplifier, front view.

the amplifier output from MINIMUM to MAXIMUM as it is adjusted from the range 0 to 100.

Electrical Cord Assembly CX-4158/U

The CX-4158/U (test probe) consists of two-conductor test cord terminated in a switchboard-type at one end and a test clip and the probe tool at the other end. The probe tool consists of a blunt brass tip fastened to a fiber handle.

Headset H-147/U

The H-147/U (test receiver) consists of a telephone receiver mounted on a headband. It is equipped with a two-conductor cord terminated on a switchboard-type plug.

Operation

Connect a tone source to the cable in one of the three arrangements below, as applicable.

LOCAL CABLE OR CABLE NOT IN USE.—Connect the tone source between one wire or a pair and ground (cable sheath) (fig. 4-57A).

PAIRED TOLL CABLE.—Connect the tone source between the wires of a pair (fig. 4-57B).

QUADDED CABLE.—Strap the two wires to each pair in the quad together and connect the tone source between the two strapped pairs (fig. 4-57C).

If a section of the sheath has been removed from the cable, bond the two ends of the cable sheath together to prevent interference in the amplifier. Place the probe tip on the cable pairs at a right angle to the cable. DO NOT TOUCH THE PROBE TIP WITH THE FINGERS, AND DO NOT ALLOW THE TIP TO MAKE CONTACT WITH THE METALLIC CONDUCTOR.

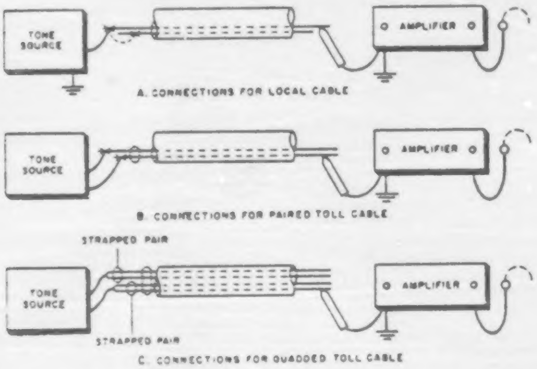

TONE SOURCE
AMPLIFIER
A. CONNECTIONS FOR LOCAL CABLE
TONE SOURCE
AMPLIFIER
B. CONNECTIONS FOR PAIRED TOLL CABLE
STRAPPED PAIR
TONE SOURCE
AMPLIFIER
STRAPPED PAIR
C. CONNECTIONS FOR QUADDED TOLL CABLE

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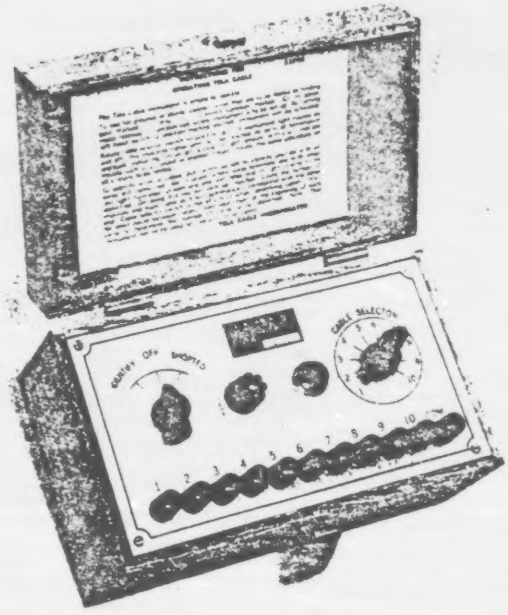
Figure 4-57.—Tone source connections.


CABLE SELECTOR
1
2
3
4
5
6
7
8
9
10

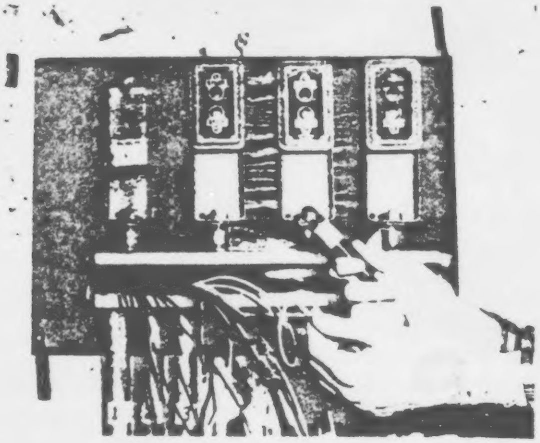
73.287X

Figure 4-58.—TELA CABLE Model 262.

Move the probe tip around the outside of the cable pairs to determine whether the wire to be located is in the outside layer. If the wire is in the outside layer, a loud tone should be heard. If no tone is heard, push the probe tip into the cable at various points until the loudest tone is heard. Then separate the pairs and test them individually.

TELA CABLE Model 262

Tela Cable Model 262 (fig. 4-58) is a portable instrument which identifies cables and detects grounds, shorts and defects very quickly and simply. One advantage this instrument affords is that testing is accomplished by using one man rather than the time-tested method of using two



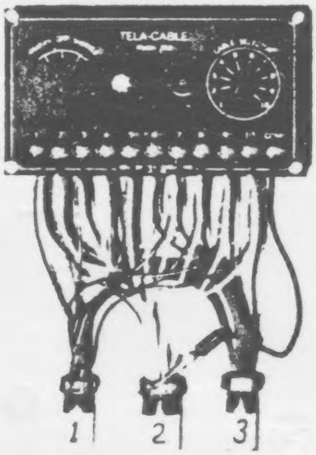
73.288X

Figure 4-59.—Test probe.

men with an elaborate procedure of communications between the two.

The instrument sends out pulsating signals which are received by a test probe (fig. 4-59). The number of pulses seen visually identify each wire of a cable when appropriate hookup is made. Figure 4-60 illustrates how as many as 30 wires or cables can be checked using only the ten binding posts on the instrument.

The procedure for using the instrument is simple. Connect the test lead from the terminal marked COM on the instrument panel to one of the following: conduit, metal raceway, shield wrapped around cable, or any other grounded equipment in the vicinity. Connect wires to be tested to binding posts 1 through 10.



73.289X

Figure 4-60.—Checking 30 wires with TELA CABLE.

Check for Grounds

To check for grounds, turn the IDENTIFY-OFF-SHORTED switch (fig. 4-58) to position marked SHORTED. This turns the instrument on. Rotate the CABLE SELECTOR switch through positions 1 to 10.

If a GROUND is present, the indicating light will come on immediately and stay lighted. The position of the CABLE SELECTOR switch will identify what circuit or wire has the GROUND. If the instrument light flashes on and off, this indicates that the signal has reached its point of termination and returned safely without being shorted or grounded out.

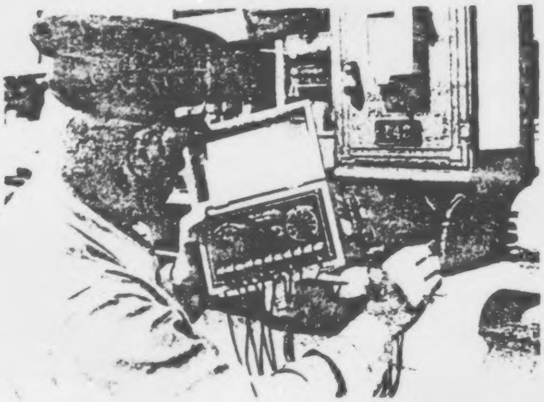
Identifying Wires and Cables

To identify wires and cables, turn the IDENTIFY-OFF-SHORTED switch to IDENTIFY with the wires still connected to the instrument. This removes the CABLE SELECTOR switch from the circuitry. Go to the points where the wire is terminated. The small test light furnished (fig. 4-61) has two leads. Ground one lead to the metal raceway or equipment ground in the vicinity. Connect the other end of the light to the unidentified wire. When appropriate hookup is made, count the number of impulses being emitted. It will correspond with the numbers at the other end automatically. Mark or otherwise identify your cable.

Wait for the short pause between cycles and then begin counting. NOTE: This instrument must be used on dead circuits or cables only. Be sure that all power is removed from the cables to be checked before applying this instrument.

CARE OF INSTRUMENTS

The instruments which have been described are delicate precision instruments which must be protected from damage causing erratic or inaccurate readings. Replacements are not

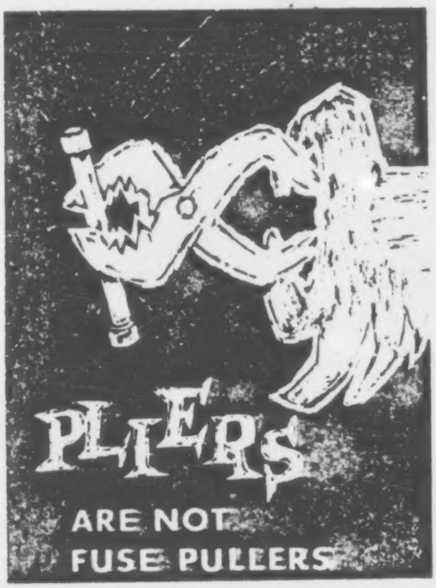


73.290X
Figure 4-61.—Identifying wires and cables.

always available, and there is always delay when an instrument must be sent for shop overhaul or repair. Even more hazardous is the possibility that an instrument may be damaged, so as to cause inaccurate readings, without anyone being aware of the fact.

The accuracy of a.c. instruments may be affected both mechanically and electrically. Mechanical factors include excessively high or low temperature, moisture, corrosion, dirt, vibration, shock, poor mechanical balance, and bending or warping of pointer or scale. Electrical factors include variations in voltage or frequency, variation in power factor, abnormal wave forms, electrostatic deflections, and (particularly) overloading.

Remember that the information given in this chapter is intended to help you to use these instruments to advantage and care for them properly—NOT to enable you to adjust or repair them. The case of an electrical measuring instrument, either switchboard-mounted or portable, must never be opened except by a qualified repairman. However, you are responsible for proper handling and maintenance.



CHAPTER 7

INTERIOR WIRING

At any Navy base, the electrical system consists of three parts: the power plant that supplies the electrical power, the distribution system that carries the electrical current from the generating station to the various buildings, and the interior wiring systems that feed the electrical power to the appliances and equipment within a building.

As defined here, interior wiring begins at the point where the distribution systems service leads are connected to the wiring from within the building and extends through each circuit of the building's interior wiring to the last fixture installation.

The interior wiring system must meet two essential requirements: it must be safe for personnel and the appliances it serves, and, further, must be capable of serving these appliances properly for as long as necessary.

In this chapter, we will discuss your responsibilities in meeting various code and specification requirements and a variety of techniques to install and repair interior wiring safely.

SPECIFICATIONS AND REQUIREMENTS

All Navy electrical installations ashore must conform to rigid standards and specifications. What are these standards? What are these specifications, and where does one find out about them?

We learned in an earlier chapter the problems that existed when draftsmen did not use the same symbols for representing certain items. This lack of uniformity applies to many different manufactured products and components.

Various engineering groups, committees, standardization boards, and government agencies have made and are still in the process of making tremendous contributions to standardization. These specifications and standards might include the physical aspects, sizes, ratings, tolerances, test methods and evaluation techniques, identification and packaging among other criteria too numerous to mention. The results achieved by rigid standardization and specifications include economy of production and substitution capability.

Although various industry and government agencies have developed many specifications and standards, to a great extent the military has established its own MIL-STDs and MIL-SPECs, which are frequently more rigid, so that the components can work in severe environmental and usage conditions.

NAVFAC SPECIFICATIONS

CE's are required to follow the specifications devised by the Naval Facilities Engineering Command when any work involving electrical apparatus, distributing systems and wiring is concerned. The latest guide in these areas is NAVFAC 9Yi (Electrical Apparatus, Distributing Systems, and Wiring, Feb. 1968). Refer to this guide for any information regarding any installation or modification of electrical equipment. Remember, that many specifications are altered periodically and you must check to see that you use the most current.

It is important to remember that MIL-STDs, federal specifications and those standards and specifications developed by the various committees, boards and codes usually apply only to specific components. NAVFAC specifications, however, are all-inclusive and advise you of those specifications (MIL-STD, federal, or commercial) you must use for particular applications. For example, NavFac 9Yi refers frequently to the National Electrical Code (NEC).

Incidentally, NAVFAC 42Y, which refers to specifications to be used for electrical accessories is also of importance to CE's.

NATIONAL ELECTRICAL CODE

The NATIONAL ELECTRICAL CODE (NEC) is prepared and published every three years by the National Fire Protection Association. Its purpose is to safeguard personnel and buildings and their contents from hazards arising from the use of electricity.

How does this code minimize the dangers mentioned above? Briefly, the NEC describes:

- a variety of wiring methods and materials,
- techniques for wiring design and protection,
- requirements of general and special equipment,
- special conditions and occupancy information, and
- a variety of tables and examples for calculations.

This wealth of information provides construction electricians with a strictly-to-be-observed guide that experience has shown will minimize electrical hazards to personnel and buildings.

If there is a disparity between the National Electrical Code and NavFac 9Yi, NavFac 9Yi assumes precedence. Navy requirements will be more rigid.

Learn the organization and contents of the NEC. Such knowledge will prove useful to you throughout your career as a Construction Electrician. As you progress in rank, you may be required to teach courses on its contents.

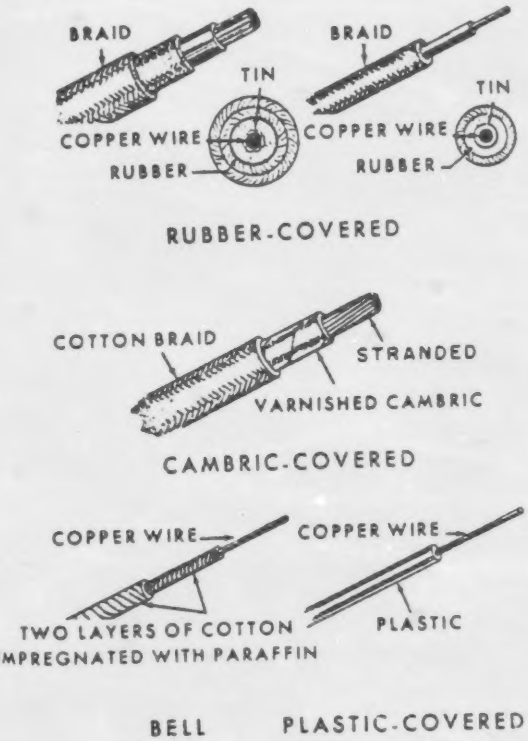
CONDUCTORS

Electrical conductors generally consist of drawn copper or aluminum formed into a wire. They provide paths for the flow of electric current and usually have insulating material (fig. 7-1) encasing the metal. The insulation material is provided to minimize short circuits and for the protection of personnel. Atmospheric conditions, voltage requirements, and environmental and operating temperatures are factors considered in the selection of the type of insulating material.

SINGLE CONDUCTORS

A conductor may consist of a single solid wire or combination of a number of solid wires (stranded) which are not insulated from each other and share in carrying the total current. Stranded conductor has the advantage of being more flexible than solid conductor, making it more adaptable for pulling through bends in conduit.

Conductors vary in diameter. Wire manufacturers have established a numerical system called the American Wire Gage (AWG) standard. Table 8 of the NEC or page 127 of Basic Electricity, NavPers 10086-B show how this numerical system eliminates the necessity for cumbersome circular mil or fractional inch diameters when describing wire sizes. Notice that the wire gage numbers increase from 1 through 18 as the diameter of the wire decreases.



73.301

Figure 7-1.—Single conductors.

The wire size most frequently used for interior wiring is No. 12 AWG, used as a solid conductor. Numbers 8 and 6 wires are normally used for heavy power circuits or as service entrance leads to buildings.

The type of wire used to conduct current from outlet boxes to sockets in the lighting fixtures is called "fixture" wire. It is usually size 16 or 18 AWG, stranded for flexibility.

CABLES

A cable is an assembly of two or more conductors insulated from each other with an additional insulating or protective shield formed or wound around the group of conductors (fig. 7-2).

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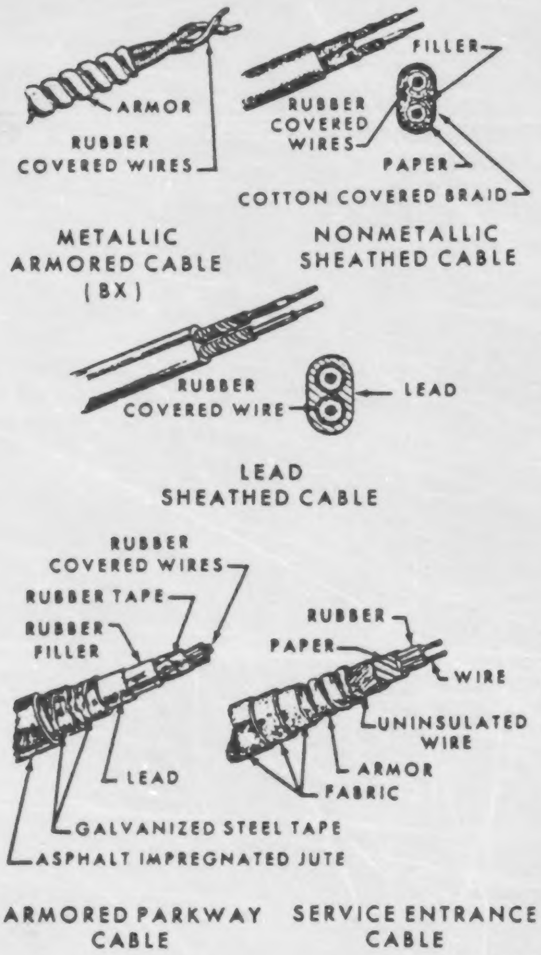
ARMOR
RUBBER COVERED WIRES
FILLER
RUBBER COVERED WIRES
PAPER
COTTON COVERED BRAID
METALLIC ARMORED CABLE (BX)
NONMETALLIC SHEATHED CABLE
RUBBER COVERED WIRE
LEAD
LEAD SHEATHED CABLE
RUBBER COVERED WIRES
RUBBER TAPE
RUBBER FILLER
LEAD
GALVANIZED STEEL TAPE
ASPHALT IMPREGNATED JUTE
RUBBER
PAPER
WIRE
UNINSULATED WIRE
ARMOR
FABRIC
ARMORED PARKWAY CABLE
SERVICE ENTRANCE CABLE

73.302

Figure 7-2.—Multiconductor cables.

The individual color conductors are color coded for proper identification.

Non-Metallic Sheathed Cable

This cable (fig. 7-2) is more commonly called by the trade name "Romex." Older manufactured cable consists of 2 or 3 conductors, insulated with rubber or thermoplastic, with paper or jute insulation wound over the rubber or thermoplastic, and an overall braid covering the combined conductors. This type of cable comes either with or without a bare (uninsulated) ground wire. The ground wire, if included, is laid in the interstices between the circuit conductors, and under the outside braid. Newer manufactured "Romex" cable is required to have the ground wire. The ground wire is used to ensure the grounding of all metal boxes in the circuit, and also furnishes the ground for the grounded-type convenience outlets which are prescribed by specification 9Yi for Navy installations. Nonmetallic sheathed cable may not be used as service entrance cable, in garages, in storage battery rooms, imbedded in poured concrete, or in any hazardous area.

Armored Cable

Armored Cable (fig. 7-2) (commonly called BX) is a combination of 1, 2, 3, or 4, insulated conductors with a wrap of paper over the conductors and an outside coat of flexible galvanized-steel armor. The flexibility of the armor makes BX easy to bend, and the armor serves as a continuous ground from outlet to outlet. Unlike rigid conduit, BX cannot be threaded, so a special type of clamp connector must be used to secure the cable to metal outlet boxes.

Armored cable and nonmetallic sheathed cable are used for temporary wiring in locations (such as in quonset huts) in which the use of rigid conduit would be unfeasible.

Flexible Cord

A flexible cord is made up of two or more conductors, each insulated from the other, and usually fine-stranded. Flexible cord is used for such purposes as the connection of portable lamps, tools, and appliances; for elevator cables; and for the connection of stationary equipment in which connections must be frequently interchanged. It must not be used as a substitute for fixed wiring; or run through holes in walls, ceilings, or floors; or run through doorways, windows, or similar openings. It may not be attached to building surfaces or concealed behind building walls, ceilings, or floors.

Finally, flexible cord may be used only in continuous lengths—meaning that splices or taps in it are forbidden.

INSULATION

Electrical conductors are made with such varicus kinds of insulation as rubber, thermoplastic,

1200

varnished cambric, paper, glass, silk, asbestos, and enamel. However, as a CE, you will be concerned mainly with rubber, thermoplastic, varnished cambric, and asbestos, in that order of frequency.

The NEC recommends insulations of various kinds for use in dry, damp, and wet locations. A dry location is one which may become only temporarily subject to dampness or wetness. A damp location requires moisture-resistant insulation because it is subject to a moderate degree of moisture. Underground installations, those in concrete slabs, masonry, in direct contact with the earth, or those areas subject to saturation with water or other liquids are considered wet locations. Such locations require either rubber covered types (RHW or RUW), thermoplastic (type TW, THW, THWN), cross-linked thermosetting polyethylene (type XHHW), lead covered aluminum sheath (type ALS), mineral insulated-metal sheathed (type MI), or a type approved for the purpose. The different insulations listed above have various maximum temperature ratings. Check the NEC to be sure you are using the appropriate insulation for the location and temperatures in which the conductors will operate.

Type RH is a heat-resistant compound which will stand higher temperatures than type R. The maximum temperature for RH is 167°F. It is used in dry locations.

Type RHW is a moisture-resistant rubber compound for use where the wire may be subject to wet conditions. The maximum temperature rating is 167°F. RHW is used in both wet and dry locations.

Type RUH is a very high grade rubber compound, consisting of 90 percent grainless rubber known as Latex rubber. This type is often used for direct burial in dry locations. Maximum temperature rating is 140°F.

Common grades of thermoplastic insulation are type T, type TW, and type TA.

Type T is suitable only for dry locations with maximum temperature of 140°F.

Type TW is moisture resistant. Again maximum temperature rating is 140°F.

Type TA is a thermoplastic-asbestos compound which combines the characteristics of Type T and type TW, and has a maximum temperature rating of 194°F. Its use is restricted to switchboard wiring.

Thermoplastic insulation has the advantages of long life, toughness, and a dielectric strength (that is, a capacity for insulating) equal to that of rubber. It requires no protective covering over the insulation.

Varnished cambric insulation is, in most respects, midway between rubber and paper in insulating quality. It is more flexible than paper but not as flexible as rubber. Its dielectric strength is greater than that of rubber, but not as great as that of impregnated paper. Varnished cambric insulation is not adversely affected by ordinary oils and greases. It is made in two types: the "standard" with a black finish, and the "heat-resisting" with a yellow finish. It is used on motor leads, transformer leads, and high-voltage cables. Its use is restricted to dry locations.

Asbestos insulation has, as the name implies, the highest capacity for resisting heat. Consequently, it is used for temperatures beyond the maximum limits set for other types of insulation. However, it is not satisfactory for damp or wet locations, and is limited to a maximum of 300 volts.

SIZE, NUMBER, AND AMPACITY

The wire size most frequently used for interior wiring is No. 12 AWG, used as a solid copper conductor. Table 310-13 of NEC, column 2, shows the allowable ampacity of a single conductor in free air, No. 12AWG, (for types RUW, T, and TW insulation) to be 25 amperes. However, the minute that conductor is not alone in free air, and is placed in a raceway, cable or direct burial, you can see, by referring to Table 310-12, that its ampacity is reduced to 20 amperes, provided that not more than three conductors are in the raceway or cable. What happens if more than three conductors are in the raceway conduit, or cable? The following table indicates the reduced ampacities for a variety of numbers of conductors in such a situation.

Number of conductors	Percent of normal current-carrying capacity
4 to 6	80
7 to 24	70
25 to 42	60
43 and over	50

Suppose, now, that you have four to six No. 12 wires in a conduit. The allowable current-carrying capacity would be only 80 percent of "normal," or 16 amps. To ensure a current-carrying capacity of 20 amps, you would have to use No. 10 wire, which has a "normal" current-capacity of 30 amps, 80 percent of which is 24 amps.

NEUTRAL WIRE

To understand the purpose of a neutral wire, bear in mind that the path traveled by electricity is always from source around the circuit and back to source. As the current follows this path, it energizes the fixtures and/or appliances that are connected into the circuit. You can see, therefore, how essential it is to ensure current return.

Generally speaking, the fixtures can be considered as resistances in series with the hot wires. In a balanced circuit, one hot wire carries the current to the load, while the other carries it back to the source.

The neutral wire ensures current return in an UNBALANCED circuit, as shown in figure 7-3. Here there are two hot wires and a neutral. There are three lamps connected across one hot wire and the neutral, and five lamps connected across the other hot wire and the neutral. These lamps occasion a current flow of approximately 1 ampere per lamp. It follows that the flow is 5 amps in one phase and 3 amps in the other—meaning that the circuit is unbalanced, with an unbalanced load of 5 minus 3, or 2 amps.

If each phase carried only three lamps, the circuit would be balanced. But because there are two extra lamps in one phase, the neutral wire must pick up the extra load and return it to the source.

Why must the neutral have the same size as the hot wires? In this case, with all the lamps on, it must handle only 2 amps, whereas the hot wire in phase B must handle 5 amps. Well, if you think about it you will realize that if the lamps in phase A were all turned off, the neutral would have to handle the full 5—amp return from phase B.

A motor in a circuit usually causes an unbalanced circuit. A motor operating on 220 volts single-phase does not have a neutral wire to aid the balance. Therefore, when a motor of this type is connected across two phases, the other phase should be given enough extra lighting load to balance the load as nearly as possible. Perfect balance is possible in theory, but not in actual practice.

With a 4-wire system, one neutral wire can be used for three circuits, provided the three are connected to opposing phases. Never use one neutral wire for two circuits connected to the same phase.

The NEUTRAL wire in a wiring system must not be confused with the equipment ground wire. The neutral wire should have white or light grey insulation; the equipment ground wire, if insulated, will always have green insulation. However, an equipment ground wire may be uninsulated.

In a 4-wire system (fig. 7-4), one of the wires is always a neutral wire, but in a 3-wire system there may or may not be a neutral wire. In a 3-wire system you may have a three-phase circuit (3 live or "hot" wires), or you may have a single-phase circuit (2 hot wires and a neutral).

INSTALLING THE SERVICE

The term "service" means, in general, the electrical system which brings the power from the pole or other point on the power line to the point in the building from which it is to be distributed to the building circuits.

The service for a building consists of two parts: the service conductors, and the service equipment. The service conductors are divided into service "drop" conductors and service "entrance" conductors. The service drop conductors are those conductors which are run from the pole to the building. The service entrance conductors are those conductors which connect the drop conductors at a point outside the building and must be run in rigid conduit to the service equipment inside the building according to NavFac specification 9Yi.

The service equipment consists of such devices as circuit breakers, switches, fuses, and their accessories, located near the point of entrance of the supply conductors to a building, and constituting the main control and means of cutoff for the electrical supply to that building.

SERVICE DROP CONDUCTORS

Service drop conductors may consist of an approved multiconductor cable or they may be open single conductors. In either case they must have thermoplastic, rubber, or other type of weatherproof insulation, except that a grounded conductor may be uninsulated if the maximum voltage to ground of any conductor does not exceed 300 volts. The current-carrying capacity of the service drop conductors must be sufficient to ensure that ample current for the

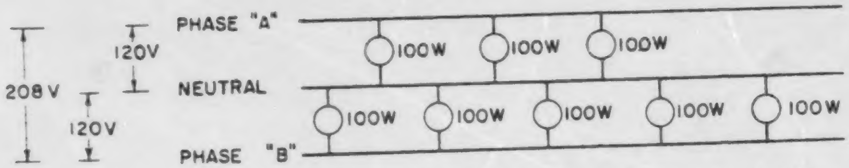

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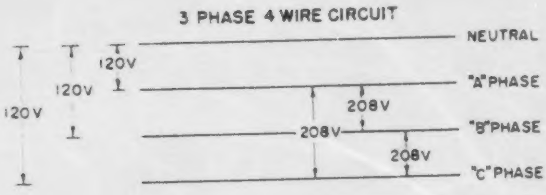
Figure 7-3.—Use of neutral wire in unbalanced circuit.



73.13

Figure 7-4.—Four-wire system.

prospective maximum load may be conducted without a temperature rise high enough to damage the insulation. Obviously, the conductors must also have adequate mechanical strength. The National Electrical Code specifies No. 8 awg wire as the minimum size, except that in special cases No. 12 may be used.

SERVICE ENTRANCE CONDUCTORS

Service entrance conductors in the Navy are single conductors run in rigid conduit; in civilian construction they may consist of an approved type of service entrance cable. Conductors also must have rubber or thermoplastic insulation, except that a grounded conductor may be uninsulated if the maximum voltage to ground of any conductor does not exceed 300 volts.

The National Electrical Code specifies No. 6 awg wire as the minimum size conductor to be used for service entrance, except that in special cases and by special permission No. 8 wire may be used. For a Navy man, special permission means that of higher authority. In civilian work (in most civilian communities the National Electric Code has been incorporated into the building laws) it means that of the community's building inspectors.

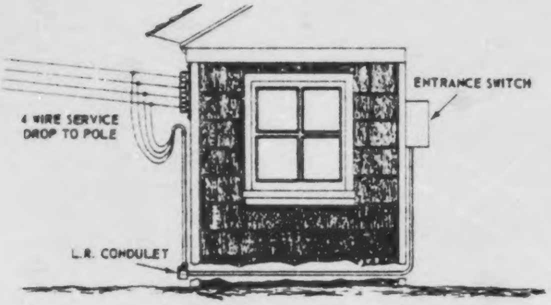
Table 1 of NEC indicates the maximum number of conductors of a given size to be used in rigid conduit for new work. Let's assume you are going to use No. 6 wire with Type THWN insulation. Using three wires (the normal number for service entrance) you see that you can use 1 inch conduit. The conduit must be continuous from the weatherhead (point where the wires enter the conduit) to the entrance switch except when a condulet (fig. 7-5) is used in place of a bend.

The conductors must be continuous from the weatherhead outside the building to the connections in the entrance service switch—meaning that no splices between these points are allowed. However, a connection is permitted, when properly enclosed, where an underground service conductor enters a building and is to be extended to the service or meter in another form of approved service raceway or service cable.

When the service is run underground, the conduit must be continuous from the pole or underground vault to the service switch. If the conduit enters the building through a concrete floor, a conduit coupling will be installed in the conduit line with the top of the coupling flush with the finished floor surface. The advantage of this is that spare conduits can be installed in the concrete floor and a plug screwed into the coupling, making a flush job. Also, if the wiring were to be removed for some reason, the open conduit could be removed from the coupling and a plug screwed into the same.

ENTRANCE SWITCHES

The disconnecting device used as a service entrance switch provides a means of disconnecting the service conductors from the supply source. It may consist of a single manually operated switch or circuit breaker. It must be a type which plainly shows whether the contacts are in an open (OFF) or closed (ON) position, as illustrated in figure 7-6.



73.8
Figure 7-5.—Service entrance with condulet.

The neutral conductor must not be run straight through the service switch, without a means of disconnection. Therefore a screw or bolted lug on the neutral terminal block should be provided for disconnecting the neutral conductor from the interior wiring system.

The NEC sets a minimum size for entrance switches at 60 amp for the fuse type and 50 amp for the circuit breaker type. A circuit breaker is a protective device which automatically opens the circuit, rather than burning out like a fuse, when the amperage exceeds that rated for the circuit breaker.

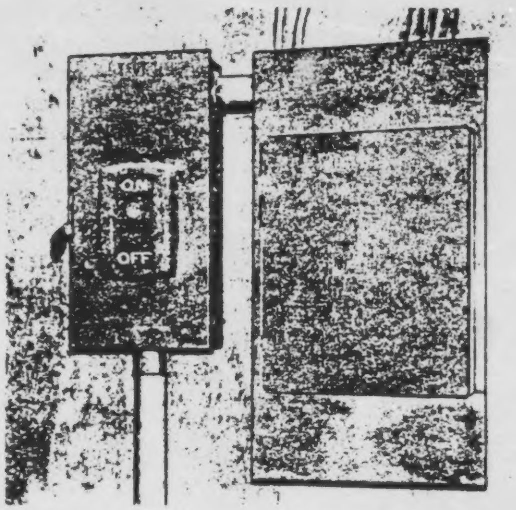
However, the NEC recommends a minimum size of 100-amp service for individual residences. An exception is that where not more than two 2-wire branch circuits are installed, a 30-amp entrance switch may be used.

No overcurrent device may be inserted in a grounded conductor except a circuit breaker which will simultaneously open all conductors of the service. EVERY ungrounded conductor must be provided with overcurrent protection.

Switches used for entrance equipment must be of a type approved for such use. An approved type is usually a quick make-and-break type with an interlocked cover which can't be opened when the switch is in ON position. The service conductors shall be connected to the disconnecting device by pressure connectors, clamps, or other approved means; but a solder lug, or other type of soldered connection, must not be used.

DISTRIBUTION PANELS

A panelboard is defined by the NEC as "a single panel or group of panel units designed for assembly in the form of a single panel including buses (buses and busways are explained in Articles 364 and 384-21 of the Code) and with or without switches and/or automatic overcurrent protective devices for the control of light, heat, or power circuits of small individual as well as aggregate capacity, designed to be placed in a cabinet or cutout box and placed in or against a wall or partition and accessible only from the front."

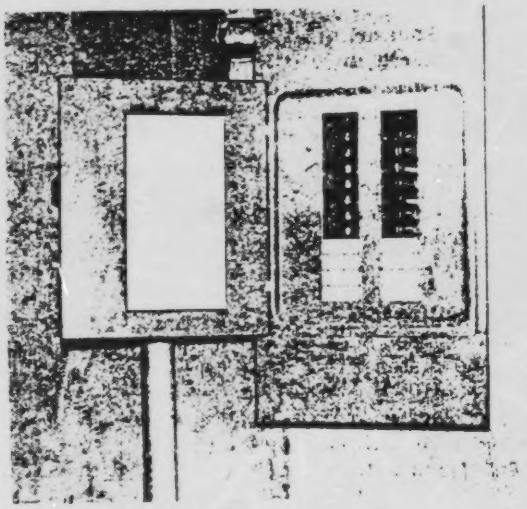


73.10
Figure 7-6.—Entrance switch showing open and closed markings.

As a Construction Electrician you will be concerned mostly with the "breaker" type panel for both light and power (see fig. 7-7). The breaker type is one which uses a thermal unit built into the switch and is preset at the factory to automatically open at a predetermined ampere setting. It may be reset to the ON position after a short cooling-off period.

Lighting panels are normally equipped with 15-amp single-pole automatic circuit breakers, while the power panels may have 1, 2, or 3 pole automatic circuit breakers with a capacity to handle the designated load. Figure 7-8 shows a typical layout for entrance switch, lighting panel, and power panel.

In most buildings the entrance switch and panelboards can be mounted close to each other. When wiring a building that has been built previously, the best way to mount the switch and

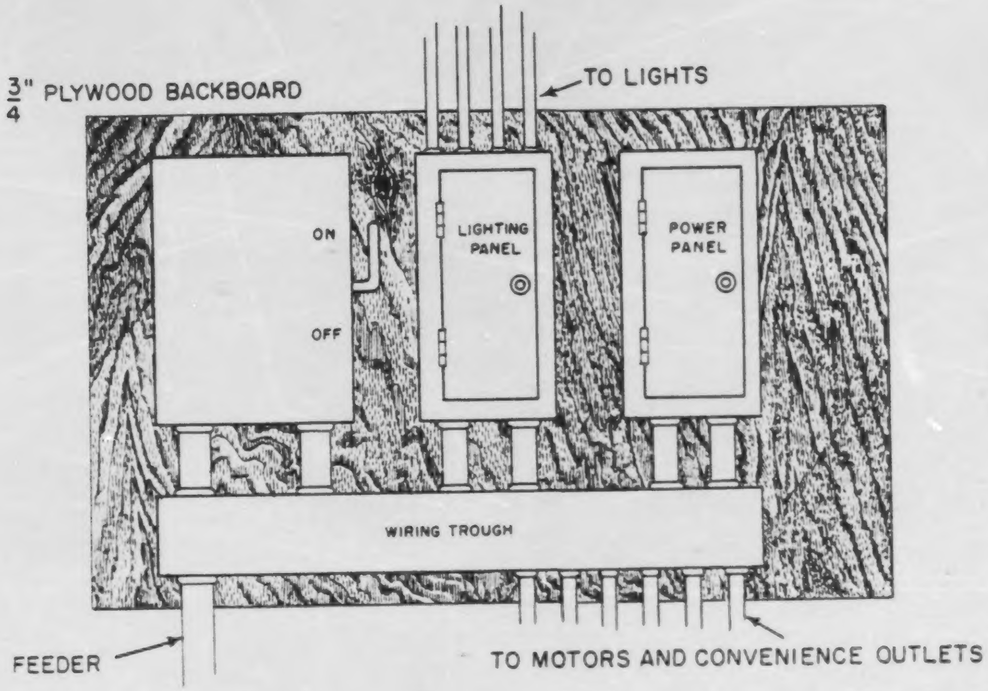


73.11

Figure 7-7.—Lighting panel.

panels is to mount a sheet of plywood for a backing board. The board should be large enough to accommodate all of the equipment, be a minimum of 3/4 in. thick, and be securely fastened to the wall with wood screws, lead anchors, or toggle bolts depending on the type of wall. The switch and panels can then be fastened to the back board with wood screws.

If you are working in a newly constructed building where only the framework has been erected, it will be a simple matter to arrange for a concealed installation. One point to remember is that there are two types of switches and panels. The recess or flush type has a front flange that extends beyond the edges of the cabinet to cover the rough edges around the cabinet where the finish wall has been cut. Also, the flush type switch has a front control for operating the switch. The surface type switch and panel has a front cover that does not extend beyond the sides of the cabinet, and the switch may be side-operated or front-operated.


$\frac{3}{4}$" PLYWOOD BACKBOARD
TO LIGHTS
ON
OFF
LIGHTING PANEL
POWER PANEL
WIRING TROUGH
FEEDER
TO MOTORS AND CONVENIENCE OUTLETS

73.12

Figure 7-8.—Representative layout for entrance switch, lighting, and power panel.

In locating panels, you must follow certain basic requirements. The panels must be placed where service and maintenance can be easily performed; they should not block any passage that is supposed to be open; they must not be in a place where they might be exposed to corrosive fumes or to dampness; and they should be located as near as possible to the center of the electrical load.

The circuits controlled at the panelboard must be clearly indicated. List them numerically, from top to bottom, with the odd numbers on the left. Put this list (called a "catalog") in the slot provided for it, as shown in figure 7-7. If possible, provide for extra circuits in the new panel to accommodate future additions.

WIRING TROUGHS

Wiring troughs are useful in any location where a large number of conduits enter a panelboard. One large conduit can be used to carry a number of conductors from the panel to the trough and smaller conduits branch out from the trough to the various circuits. The trough can also be used for feeders from the entrance switch to the panelboards. Figure 7-8 shows a wiring trough used in this manner.

INSTALLING WIRING

For any type of interior wiring installations, the next step after installing the service is to install the outlet, receptacle, and switch boxes (fig. 7-9). A box is simply a metal container, set flush or nearly flush with the wall, floor, or ceiling, into which the outlet, receptacle, or switch will be inserted and fastened. In figure 7-9A is a 4-in. octagon box used for ceiling outlets. This box is made with 1/2-in. or 3/4-in. "knockouts,"—that is, indentations which can be knocked out to make holes for the admission of conductors and connectors. Box B in figure 7-8 is a 4 11/16-in. square box used for heavy duty, such as for a range or dryer receptacle. It is made with knockouts up to 1 in. in diameter. Box C is a sectional or "gem" box used for switches or receptacles. By loosening a screw you can remove a side panel, so that two or more boxes can be "ganged" (combined) to install more than one switch or receptacle at a location. Box D is a utility (called a "handy") box, made with 1/2- or 3/4-in. knockouts and used principally for open-type work. Box E is a 4-in. square box with 1/2- or 3/4-in. knockouts, used quite often for switch or receptacle installation. It is equipped with plaster rings having flanges of various depths, so that the box may be set in plaster walls of various thicknesses.

Besides the boxes shown, there are "special" boxes for switches when you have more than two switches at a location. These are called "conduit gang boxes," and they are made to accommodate 3, 4, 5, or 6 switches. Each size has a cover made to fit.

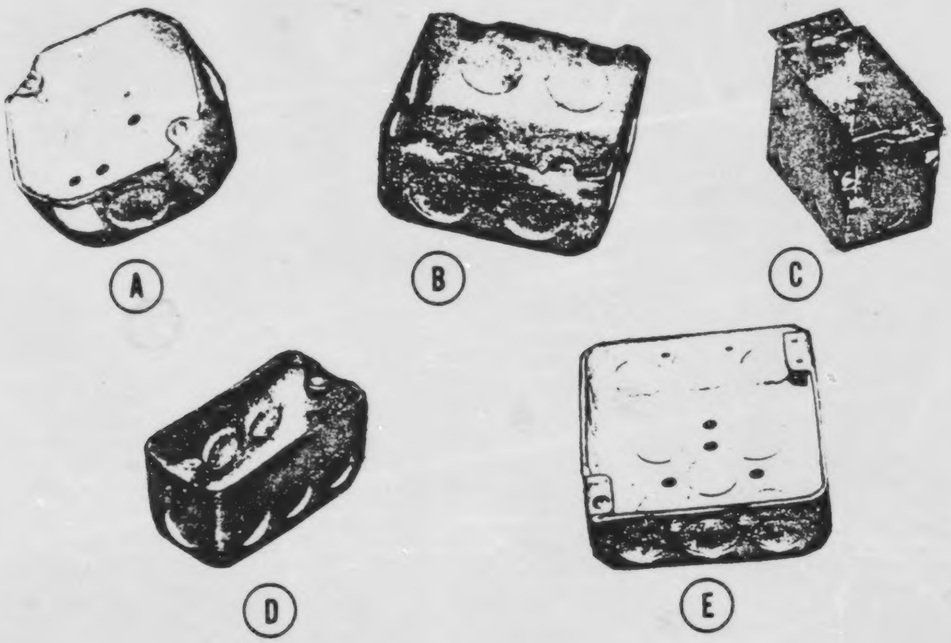
A ceiling box may be fastened to a wooden "header" set between the ceiling joists, or it may be fastened to a "bar hanger" as shown in figure 7-10.

To locate outlet, receptacle, and switch boxes you follow the electrical floor plan, which shows the locations of all of these. Assume you are working on a new building in which all wiring will be concealed by wall, ceiling, or floor covering. Specification 9Yi requires that the outside edges of outlet and switch boxes without flush plates shall not be recessed more than 1/4 in. below the surface of the finished wall. Boxes having flush plates shall not project beyond the finished wall surface. Wall outlets are to be located the following distances above finished floor surfaces: duplex receptacles, 12 in.; toggle switches, 48 in.; wall fan receptacles, 78 in.; overcounter receptacles, 46 in. All these measurements are from the finished floor surface to the middle of the receptacle. The usual way to mount a wall box in a frame wall is on a wood header inserted between studs.

For exposed wiring installed in a building after completion of the wall finish, the procedure for securing boxes varies according to the wall or ceiling surface material. Boxes are fastened to a wood surface with wood screws; for plaster board or plywood, toggle bolts are better; for concrete you must drill holes for setting lead anchors.

RIGID CONDUIT

Rigid steel conduit may be either black-enamel finished, sherardized (zinc-coated by heat), or galvanized. Black enamel and sherardized is not used much in the Navy, because it deteriorates in damp locations or when exposed to the elements. The galvanized type can



73.15

Figure 7-9.—Types of outlet, receptacle and switch boxes.

be installed outside, inside, or imbedded in concrete, even in wet locations.

When conduit is installed in concrete, it must be imbedded in the concrete, not in any cinder bed below it. In some overseas locations the conduit must be given a good coat or red lead or asphalt paint as a preservative against corrosion caused by beach sand used in the concrete and/or chemicals in the soil.

Rigid conduit comes in 10-ft lengths, threaded on both ends, and each length has a coupling on one end for joining lengths together. Sizes range from 1/2 in. to 6 in. in diameter.

Rigid pipe may also be purchased in plastic and aluminum. Installation requirements for plastic (nonmetallic polyvinyl chloride) are covered in Article 347 of the NEC; installation requirements for aluminum in NavFac Specification 9Yi.

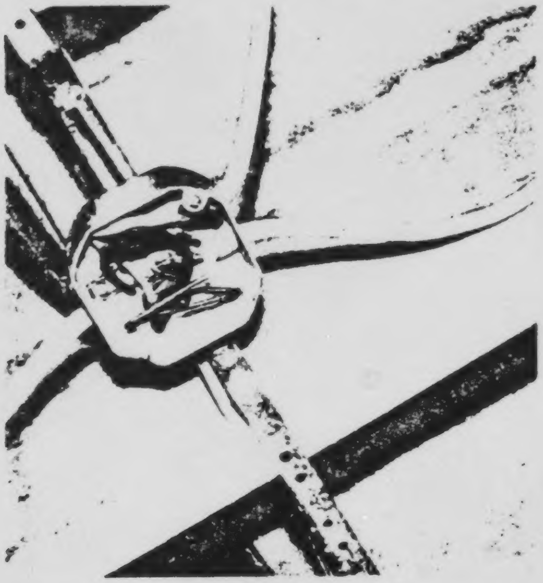
Cutting and Threading Rigid Conduit

The use of rigid conduit involves a good deal of cutting and threading of lengths. It is best to cut with a hacksaw or special conduit cutter. An ordinary revolving wheel-type pipe cutter leaves a heavy inside ridge that is difficult to remove and tends to jam the passage through of conductors. Always ensure that you make a cut at right angles to the axis of the pipe.

After the pipe is cut to the proper length, use a reamer to remove all burrs from the inside of the sawed end. The conduit should be held in a vise during cutting and reaming. If a regular reamer is not available, a large rat-tail or half-round file can be used to remove burrs. However, no matter what burring tool you use, you must get a smooth inside finish to allow the passage of the conductors.

The next step is thread-cutting on the cut-off end. For the smaller pipe you use a ratchet-type die that turns directly with the handle. On larger pipe you use a die with a mechanical advantage—that is, one on which the die makes only a part of a revolution when the handle makes a complete revolution.

A conduit-threading die, like a plumber's die, makes a tapered thread, so that a coupling



73.16

Figure 7-10.—Ceiling outlet box on bar hanger.

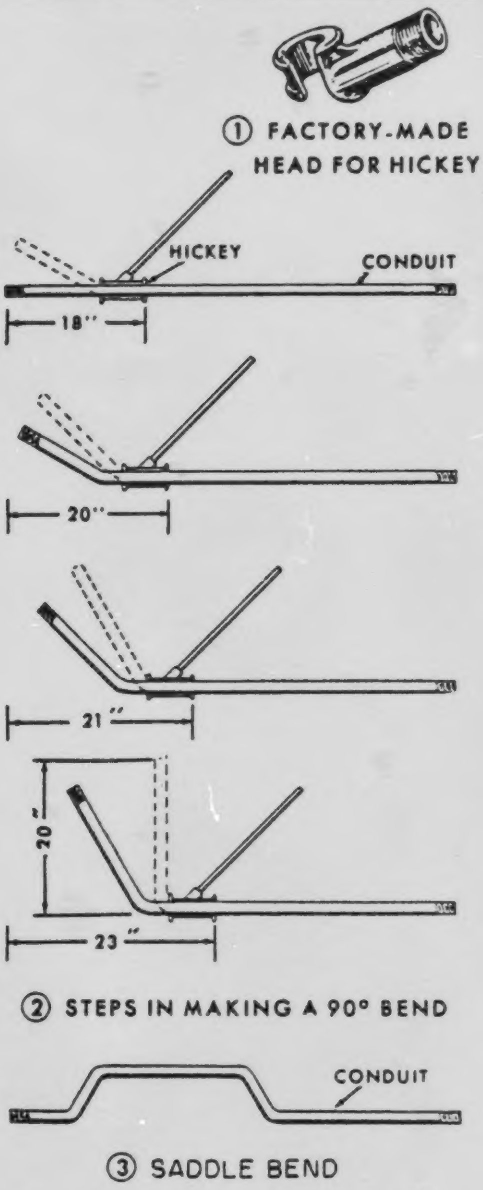
starts rather loosely but binds hard as it is set up. This tight connection serves two purposes: (1) it makes a watertight joint, and (2) it makes a good electrical connection for a continuous ground throughout the length of the conduit. To ensure a tight connection when it is impossible to screw a piece of pipe into a coupling, a special type of split coupling called "Erickson" coupling is used. It is somewhat similar to a water-pipe union, but is used without gasket or ground joint.

Manual Bending

In any conduit job you will have to make bends of various shapes, such as right-angle or 90-degree bends, offsets, and saddles. For the smaller pipe this is done with a bending tool which is commonly called a "hickey." This can be slipped over the conduit (fig. 7-11).

When bending conduit beyond 90° never make a sudden, sharp bend which may cause flattening of the pipe. Make a bend in a series of gradual movements. Bend a small amount; then move the bender a short distance and bend again.

The procedure illustrated in figure 7-11 is recommended as one method of making a right-angle bend in a length of 1/2-inch conduit. If a 90-degree bend is to be made in a length of conduit at a distance of 20 inches from one end, the electrician must:



① FACTORY-MADE HEAD FOR HICKEY

② STEPS IN MAKING A 90° BEND

③ SADDLE BEND

73.304

Figure 7-11.—Bending rigid conduit.

(a) Mark off 20 inches from the end of the conduit.

(b) Place the conduit hickey 2 inches in front of the 20-inch mark and bend the conduit about 25 degrees.

(c) Move the bender to the 20-inch mark and bring the bend up to 45 degrees.

(d) Move the bender about 1 inch behind the 20-inch mark and bring the conduit up to 70 degrees.

(e) Move the hickey back about 2 inches behind the 20-inch mark and bring the bend up to 90 degrees.

Miscellaneous conduit bends (offset bends, figure 7-11) can be made more accurately if the contour of the bend is drawn with chalk on the floor and the bend in the pipe is matched with the chalk diagram as the bend is formed. Conduit in excess of 1 inch is usually bent by a hydraulic bender.

Hydraulic Bending

A hydraulic bender speeds conduit and pipe installations by application of a powerful, smoothly applicated force to the pipe, resulting in accurate bends without kinks or damage.

A portable hydraulic bender may be operated by a suitable electric motor, or manually by a hydraulic hand pump. A bending ram assembly which can be quickly disconnected completes the unit. For a single conductor which is not lead covered, the bend must have a minimum radius of six times the inside diameter of the pipe; for lead-covered conductors the radius of a conduit bend must be at least ten times the inside diameter of the conduit. Figure 7-12A illustrates what is meant by the radius of bend. Making a quick, neat bend is a job that requires a lot of practice.

Condulets

Condulets are a very convenient way of making bends, especially in conduit which will be exposed to the elements. However, a condulet must never be concealed, in a wall or elsewhere, because the cover must always be accessible. Condulets may be used to reduce the number of bends made in a run of conduit. The Code specifies not more than four 90-degree bends between pull boxes (pull boxes are explained in NEC Article 370-18), but a condulet may be used in place of a pull box.

The L type of condulet shown in figure 7-13 is very convenient for sharp corners.

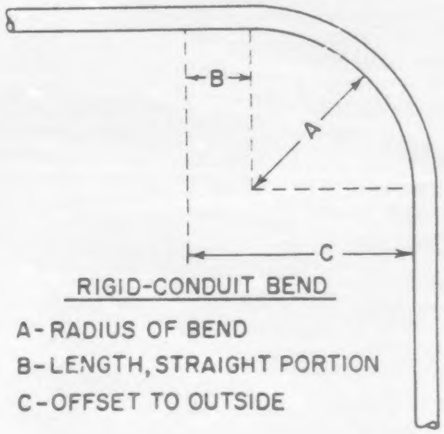


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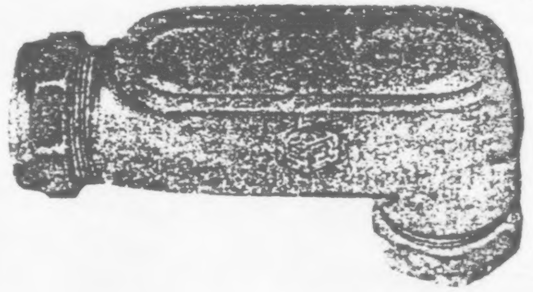
Figure 7-12.—Dimensions of a conduit bend.



73.18

Figure 7-13.—LR condulet.

Figure 7-13 actually shows an LR type, which can be opened at the back to allow the wire to be pulled without binding against the conduit wall. In using condulets, be sure that covers are set on securely. For condulets exposed to the elements, place a gasket under the cover to ensure watertightness.

Neatness is a must in bending, conduit work, and any other electrical work. Bends which are not uniform detract, from the appearance of the job. The method of securing conduit depends on it's size and type. A one-hole strap is the type of fastener most frequently used. The manner of fastening depends on the material to which fastened. Hollow walls require toggle bolts; concrete or block walls require a lead anchor set in a drilled hole; steel construction requires a bolt set in a drilled hole.

Explosion-Proof Fittings

In locations specified by the NEC (Articles 510 through 517) as explosion-hazardous you must install explosion-proof fittings. Locations are classed by number in descending order of dangerousness, as: class 1, division 1, highly hazardous; class 1, division 2, slightly less hazardous and so on.

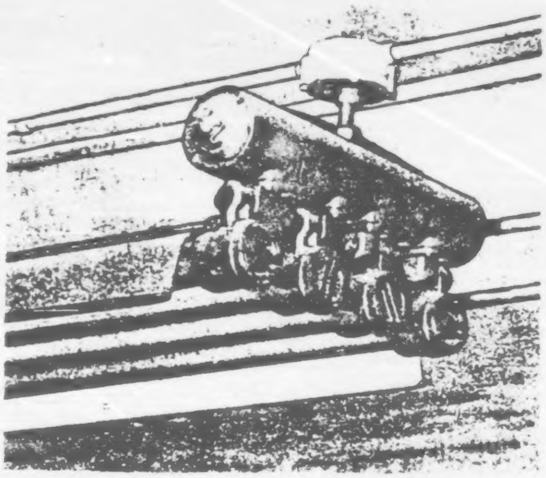
As an example of explosion-proofing: in a gasoline filling station the pump island is classed as class 1, division 1. All conduits in this area must be sealed with a special type sealing fitting, and on conduit for lights above the pumps the sealing fitting must be located at a height of not less than 4 ft above the driveway surface. No junction boxes (explained in NEC Article 370-18) or condulets may be used in the pump island area. Conduits running from pumps to panels in the building must be sealed not less than 18 in. above the building finished floor to avoid fumes from the gasoline pumps. An approved seal must also be installed on any conduit entering or leaving a dispensing pump or other enclosure on the pump island.

Inside the building of a gasoline station the class 1, division 1, space extends 18 in. above the floor. The space above the 18-in. level is classed as class 1, division 2.

Paint spray booths are listed as class 1, division 1, and therefore all fixtures, exhaust fans, air compressors, or other electrical appliances located in such booths must be explosion-proof, as well as all switches, convenience outlets, and motor starters.

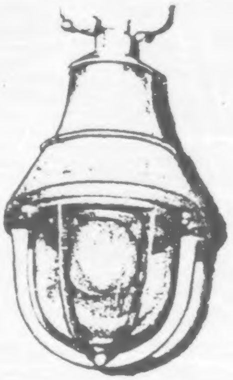
Figure 7-14 shows an explosion-proof fluorescent lighting fixture for installation in a paint spray room. In this fixture the fluorescent tubes are sealed in a larger glass tube. The four tube seal ends can be seen in the figure. The ballast (explained in NEC Article 410 Part P) is enclosed in the container above the tube seals.

Figure 7-15 shows an explosion-proof incandescent lighting fixture; figure 7-16 an explosion-proof off-and-on switch for lighting.



73.19

Figure 7-14.—Explosion-proof fluorescent fixture.



73.20

Figure 7-15.—Incandescent explosion-proof fixture.

THINWALL CONDUIT

Conduit consisting of electric metallic tubing in sizes from 1/2 in. to 4 in. in diameter is called "thinwall conduit." Thinwall conduit cannot be threaded, so a special type of fitting must be used for connecting sections together or connecting pipe to boxes. The type most commonly used is the "compression" type, which is waterproof. Other types, called the

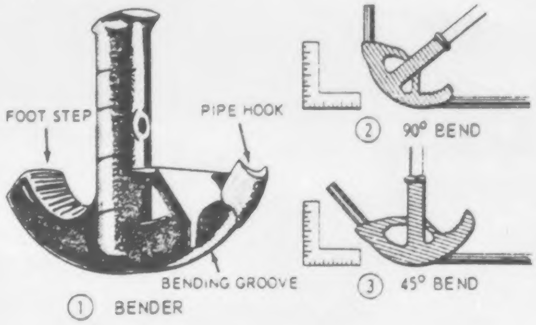
73.21
Figure 7-16.—Explosion-proof on-and-off lighting switch.

"indenter" type and the "setscrew" type, are not waterproof.

Again you cut thinwall conduit with a hacksaw keeping the cut at right angles to the axis of the pipe. Thinwall is bent with the special bender shown in figure 7-17. A different size bender for each size of pipe is required!

FLEXIBLE CONDUIT

Flexible conduit (also called "Greenfield") is composed of a spirally wrapped metal band wound on itself and interlocked so as to make a cylindrical metal flexible tube of high mechanical strength. Greenfield can be used in locations to which rigid conduit could not be adapted. It is easily fished, requires no elbow fittings, and comes in diameters from 1/2 in. to 3 in.



73.22
Figure 7-17.—Thinwall bender.

The only fittings required for Greenfield are squeeze-type fittings for connecting the pipe to boxes. A fine-tooth hacksaw should be used for cutting, and again the cut should be square.

Greenfield is made in two types: the standard unfinished-metal type, and a moisture-resistant type called "sealtite" which has an outside jacket of latex or plastic. The moisture-resistant type is not intended for general use, but only for connecting motors or portable equipment in damp or wet locations where flexibility of connections is desired. It must be used with connectors approved for the purpose.

The standard metal Greenfield is used primarily for connecting motors mounted on sliding bases, or for equipment which cannot be easily wired with rigid conduit and requires conduit which can be fished in walls or between floor above and ceiling below. It is seldom used in wet or hazardous locations except as expressly permitted by the Code.

RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

PVC conduit has been developed by many manufacturers. Some of the advantages this type of conduit offers include the lighter handling weight, high corrosion resistance, ease of installation, leakproof joints and easy wire pulling due to the mirror like walls. Refer to NEC, Articles 347, 514-8, and 515-5 for installation requirements.

Joining PVC

Permanent joints are made quickly in PVC conduit by cutting the conduit with a hand or hack saw and removing the burrs with a pocketknife. The surfaces to be joined are wiped clean and a light coat of solvent cement is applied to the inside of the coupling or fitting and outside of the conduit. After the conduit is inserted all the way into the fitting, give it a quarter turn to ensure good distribution of the cement. Any excess is wiped off.

A variety of threaded PVC fittings is available from manufacturers. Their use is covered in Article 370 NEC. Installation using the solvent-welding technique described in the previous paragraph, however, is preferred because the joints are water and vapor proof.

Bending PVC

Bending is accomplished very easily by application of heat from a hot-air cold-air blower to a section of PVC rigid conduit. Gradual pressure is applied to form the bend desired. When the desired curve is achieved, the cold air from the blower is then applied to set the bend. Be sure to compensate for any spring back. Remember too, that PVC conduit should be bent on a minimum radius at least 10 times its diameter.

ROMEX CABLE

"Romex" is made in sizes 14 to 2 awg and having 2 or 3 conductors. Sizes 14, 12, and 10 are solid wires. Sizes 8 to 2 awg are stranded conductors to a cable. Romex must be secured at intervals of not more than 4-1/2 ft and within 12 in. of each outlet box of fittings, except where finished in walls.

In naval installations Romex is used primarily for temporary work, such as on quonset huts. Civilian contractors, however, use it extensively for residential wiring; but the NEC does not permit its use as service entrance cable, in commercial garages, in theaters built for more than 200 spectators, in storage battery rooms, in any hazardous location, or imbedded in concrete. All connections in Romex must be made at junction or outlet boxes, and squeeze-type connectors must be used for securing the cable to boxes.

In most installations where Romex is permitted a ground wire must be used with the cable to furnish a continuous ground throughout the circuit. This ground wire is fastened under a screw in each outlet box to which the cable is connected. Another way to secure the ground wire is to wrap it backward over the braid in a close wrap and under the Romex clamp. This makes a very good bond. When using grounding type duplex receptacles, the ground wire can be fastened under the green grounding screw.

When making bends in Romex, the radius of the bend should be not less than five times the diameter of the cable.

BX CABLE

BX, an armored metallic cable, is also used on naval installations for temporary wiring but, unlike Romex, its use in civilian installations is restricted. Most city building codes restrict the use of BX to oil burner control circuits and the like. A difficulty with BX is the fact that it tends to ground after installation. Small metal burrs on the armor can, because of vibration, penetrate the insulation and cause a ground. The trouble and expense involved in clearing a ground behind the wall covering, after a building is finished, can be easily imagined.

BX, like Romex, must be run continuous from box to box, with no splicing allowed between boxes. It must be secured at intervals not greater than 4 1/2 ft and within 12 in. from each outlet box or fitting, except where fished in walls. It must be secured to boxes with a squeeze-type connector. It is cut with a fine-tooth hacksaw, and a fiber bushing is installed over the conductors at each cut.

BX comes in sizes from 14 to 2 awg and in cables containing 1, 2, 3, or 4 conductors. The armor on the cable furnishes a continuous ground between boxes.

LOCATING AND INSTALLING CONDUCTORS

When the service switch, panelboards, and conduits have been installed, you are ready to pull in the wires. The electrical print or plan shows the number of wires to be pulled into each individual conduit. Remember that there must always be a neutral wire in any lighting or convenience outlet circuit.

Lighting fixtures and convenience outlets are connected between a neutral and a hot wire, with the wall switches connected in series with the hot wire. Any solid color except white or green can be used for the hot wire, except that in switch leg wiring using cable the return leg must be black. The neutral wire is always white, and equipment grounds always green, if

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insulated. The accepted wire color code is in NEC Article 210-5.

Wires are pulled through conduit with a narrow steel tape called a "fish" tape. Fish tapes come in various thicknesses; on most jobs you will use the small 1/8 by 1/16 in. size.

Start this tape through the conduit at an outlet box or panelboard, as the case may be, and keep pushing the tape until it emerges at the next opening or outlet box. You secure the wires to a hook on the fish tape by removing about 3 in. of insulation from the wires and bending the bare wires over the hook. Make a few wraps of friction tape over this connection, to prevent the wires from slipping off and to provide a smooth pulling surface. In some cases you may have to put talc or a lubricant called "pulling compound" on the wires. Never use oil or grease for this purpose, because these substances will deteriorate the insulation.

Proceed now to pull the tape back through the conduit and, of course, the wires with it. If possible, have a man at the point where the wires enter, to keep out kinks or twists. Where wires pass through an outlet box without being tapped, pull enough wire to continue on through without making a splice, so as to eliminate extra splices in the box or opening.

When the wires have been pulled in throughout the conduit system, connect the proper wires to the various fixtures and outlets. Do any necessary splicing at the same time. In splicing, remember that white wires connect to white except for Romex cable switch runs and other colors to the same colors. In splicing joints, always be sure the joint is well soldered and taped with rubber or friction tape—or, in some places, you may use a plastic electrical tape which does not require a cover of friction tape.

Another way of insulating splices is with an insulated wire connector called a "wire nut" (fig. 7-18A). You screw this device onto the bare end of a conductor. Wire nuts do not require tape if the conductor ends are cut short enough to prevent them from extending outside the nut.

A wire nut is but one type of "solderless connector." Another type is shown in figure 7-18B. It grips the wires like a vise, producing such good metal-to-metal contact that it is unnecessary to use solder. All you have to do is apply the connector to the wires, and then cover the joint with tape. Of course, you must prepare the wire ends just as you would for a soldered splice.

There are other types (fig. 7-18C) of solderless connectors, but all operate on the principle of gripping or pressing the conductors. They save time and provide as high mechanical strength as soldered splices.

When installing Romex or BX, make sure that the conductors do not come in contact with metal pipes, and that they are supported properly, with no sag between supports. Exposed wiring in basements or attics is best protected by carrying the wire alongside joists or rafters. Where wires run across these timbers, you can carry it through bored holes. However, figure 7-19 shows how wire can be carried across timbers on a "running board."

Flexible cords on portable equipment must never be subject to mechanical strain. They must be kept as short as possible. All cords must be 3-wire, with the third wire grounding the equipment on one end and terminating at the grounding screw in a 3-wire grounding-type attachment plug.

SWITCHES

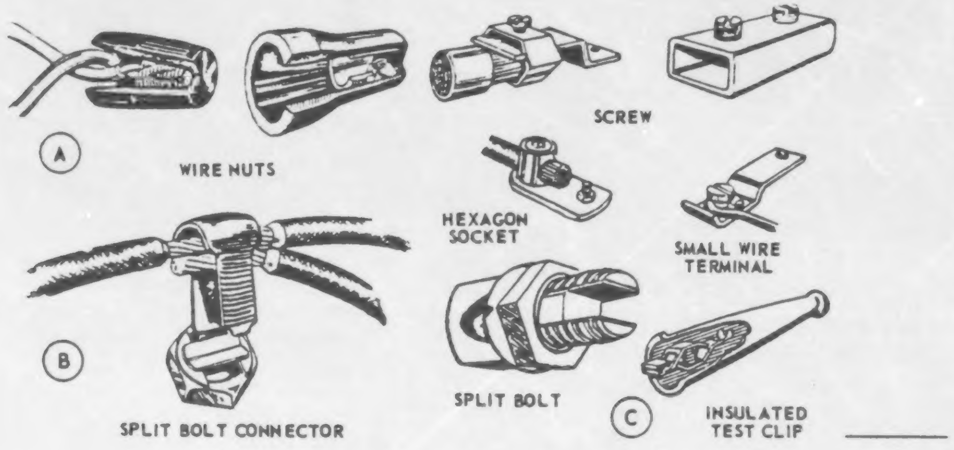
For interior wiring you use single pole, 3-way, or 4-way "toggle" switches. Most of the switches you use will be singlepole, but occasionally you will have to install a 3-way system and on rare occasions a 4-way system. Still another system of switching, called the "low-voltage" system, is coming into use.

A single-pole switch is simply a one-blade on-and-off switch which may be installed singly or in multiples of 2 or more in the same metal box. Boxes were previously explained in this chapter. In wiring a single-pole switch, connect the colored wires to the two contacts on the switch, the switch being always in series with the hot wire. Figure 7-20 shows a single-pole switch circuit.

In a 3-way switch circuit there are two positions, either of which may be used to turn a light on or off. The typical situation is one in which one switch is at the head of a stairway and the other at the foot. Figure 7-21 shows how the circuit functions.

Terminals A and A' are the common terminals, and switch operation connects them either to B or C and B' and C' respectively. Either switch will operate to close or open the circuit, turning the lights on or off.

By tracing the circuit in figure 7-21 from the source, you can see that the hot wire goes to the first switch, through the closed switch blade to



73.305

Figure 7-18.—Cable and wire connectors.

the other switch by way of the traveler, and through this switch to the light. By changing the position of either of the switches, the circuit is broken.

A 4-way switch is an extension of a 3-way circuit by the addition of a 4-way switch in series with the two traveler wires. Figure 7-22A shows how a 4-way circuit is wired. By tracing this circuit from the source you observe the hot wire connected to switch (C) passing through position 1, which is closed. The hot wire continues to point 4 on the 4-way switch (B). At this time the toggle on switch B is in the UP position and contact is made from point 4 to point 3. The hot wire continues on through the traveler to switch (A), and through position 2 (which is closed) to the light.

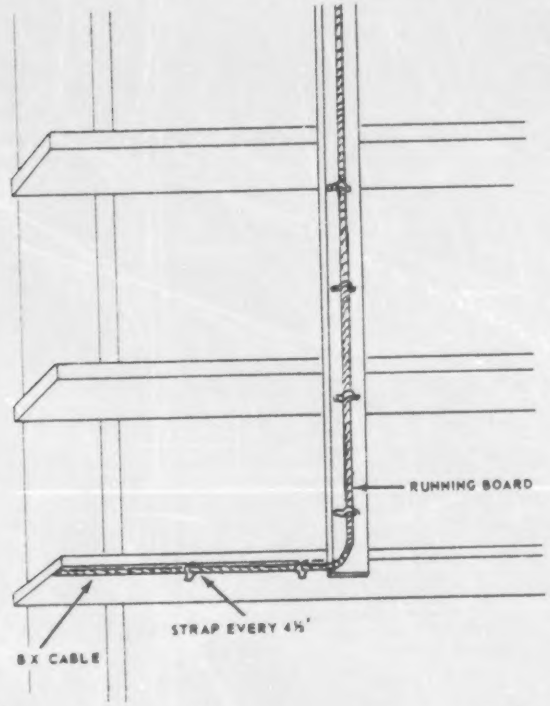
Suppose, now, that you want to turn the light off at 4-way switch B. By putting the toggle in OFF (down) position you change the switch blades from point 1 to 2 and 3 to 4 to points 1 to 4 and 2 to 3 (see fig. 7-22B). If you now retrace the circuit from switch B to switch A you will find that it goes from point 4 to point 1 on switch B and through the traveler to switch A, where the circuit is broken by the blade in open position.

Most 4-way switches have a wiring diagram on the switch body. Some, however, have the diagram on the carton the switch is packed in. This must be preserved. If it gets lost, you will have to use an ohmmeter or battery to trace the movement of the blades when you change the position of the toggle.

Note that 3- and 4-way switches may be used as single-pole switches, and 4-way switches may be used as 3-way switches. Some activities may install all small-wattage, 4-way switches for all lighting circuits, to reduce their inventories. However, 3- and 4-way switches are usually larger than single-pole switches and take up more box room. The size of a switch depends on its ampacity (rated maximum amperage). The ampacity and maximum allowable voltage are stamped on the switch, and must be considered when ordering equipment for the job.

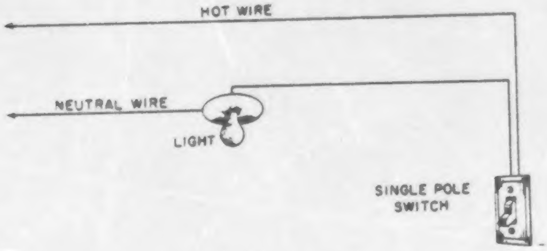
"Low-voltage" wiring is a switching system which employs a transformer and low-voltage relay. A low-voltage conductor (three No. 18 awg wires) is used from the outlet to the switch box instead of conduit or Romex. Some systems use a master transformer to reduce the voltage from 110 volts to 6 volts, but one system uses a combination transformer and relay (a relay is a protective device which opens a circuit when current in a line exceeds the rated value of the relay at the outlet box. By using this individual transformer, only one light would be affected in case of transformer failure.

The transformer-relay combination is installed in the outlet box for the light being controlled, with the transformer inside the outlet box and the relay protruding outside through a knockout, as shown in figure 7-23.


RUNNING BOARD
STRAP EVERY 4½'
BX CABLE

73.23

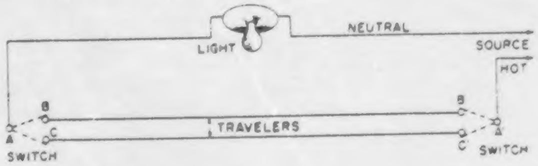
Figure 7-19.—Wires carried across timbers on running board.


HOT WIRE
NEUTRAL WIRE
LIGHT
SINGLE POLE SWITCH

73.24

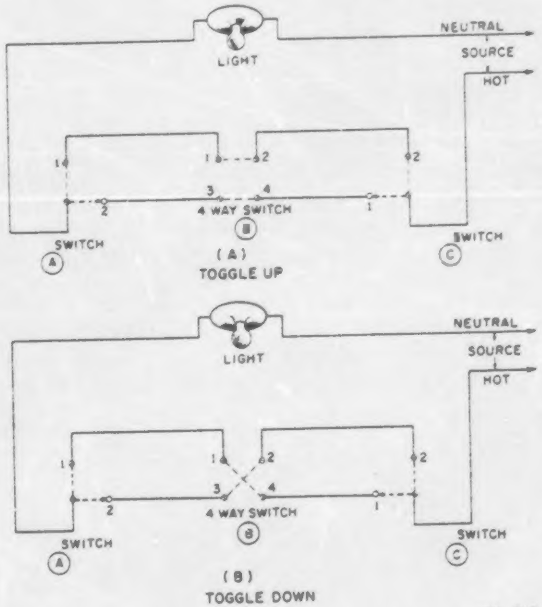
Figure 7-20.—Single-pole switch circuit.

With the low-voltage system, as many switches as are required can be installed for any given light, or a master switch can be installed to turn on as many as eight lights simultaneously. There is no necessity for 3-way or 4-way switches, because the switches are connected in parallel, and the movement of the switch toggle in one direction pulls the relay one way (off the circuit) and energizes the light.


LIGHT
NEUTRAL
SOURCE
HOT
B
A
C
TRAVELERS
B
C
A
SWITCH
SWITCH

73.25

Figure 7-21.—Three-way switch circuit.


LIGHT
NEUTRAL
SOURCE
HOT
1
1
2
2
3
4
2
1
4 WAY SWITCH
B
SWITCH
A
SWITCH
C
(A)
TOGGLE UP
LIGHT
NEUTRAL
SOURCE
HOT
1
1
2
2
3
4
2
1
4 WAY SWITCH
B
SWITCH
A
SWITCH
C
(B)
TOGGLE DOWN

73.26

Figure 7-22.—Four-way switch circuit.

A movement of the toggle in the other direction pulls the relay the opposite way (into the circuit) and breaks the circuit.

RECEPTACLES

The several types of receptacles used in interior wiring are discussed below in the order in which they are most commonly used.

A "convenience outlet" (fig. 7-24) is a duplex receptacle with two vertical or T slots and a round contact for the ground. This ground is connected to the frame of the receptacle, and is grounded to the box by way of the screws that secure the receptacle to the box.

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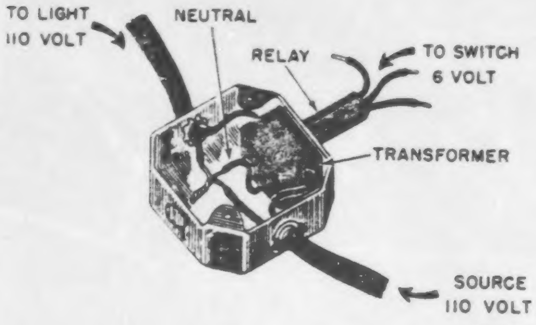
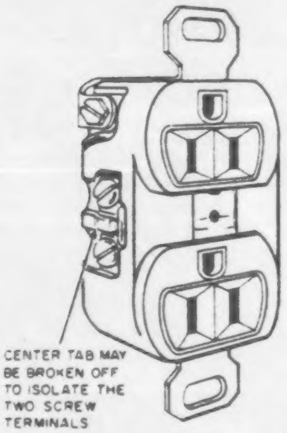


73.27
Figure 7-23.—Low-voltage relay and transformer.

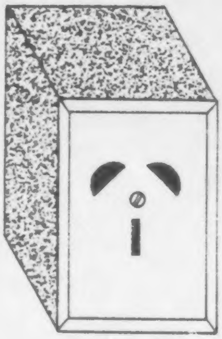

CENTER TAB MAY BE BROKEN OFF TO ISOLATE THE TWO SCREW TERMINALS

73.28
Figure 7-24.—Duplex convenience outlet.

When you desire to have the two outlets on a receptacle supplied by two separate power sources, break the center tab between the two screw terminals on each side. Then, wire the same as you would single outlets (fig. 7-24).

Most floor receptacles are single receptacles with two vertical or T type slots.

A "range receptacle" (fig. 7-25) may be a surface type or a flush type. It has two slanted contacts and one vertical contact, and is rated at 50 amps. Receptacles for clothes dryers are similar, but rated at 30 amps. Range and dryer receptacles are rated at 250 volts, and are used with three wire 115/230 volts, two hot wires and a neutral. A receptacle for use with an air conditioner taking 230 volts is made with two horizontal slots and one round contact for the ground.



73.29
Figure 7-25.—Range receptacle.

When the interior wiring system has been completely installed, make an overall inspection to be sure that good installation practices have been observed and that all connections are correct. While making this check, don't forget neatness. Make sure that ground connections are tight and that ground wire is protected against injury. Be sure that all connections in entrance switch and panelboards are tight. See that all metal noncurrent-carrying parts of portable equipment are grounded.

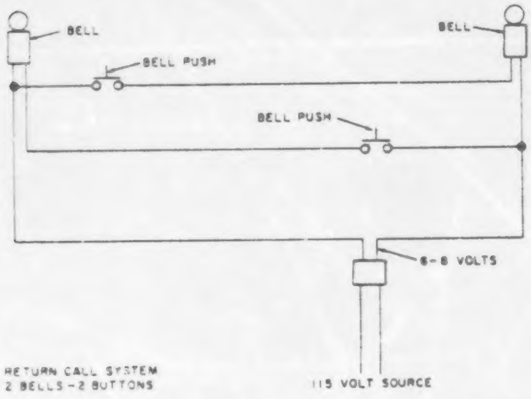
CALL SYSTEMS

The simple buzzer call system is merely a bell or buzzer and a pushbutton switch wired in series in the wires from a transformer. A call system transformer reduces voltage from 110 to 6 or 8 volts.

A "return" call system is often used in offices located in the same building (because of the low voltage, there would be considerable line loss if the bells were far apart). In a return system a call sounded from one bell push can be answered by a call sounded from another. Figure 7-26 shows a wiring diagram for this type of circuit.

MOTOR BRANCH CIRCUITS

As a CE you will frequently have occasion to wire in, connect, and service motors of various sizes and voltages. A motor branch circuit consists of the following elements: circuit



73.30

Figure 7-26.—Return call system.

conductors, overcurrent protective devices, means for disconnection, controller, and motor running protection.

The circuit conductors are the wires from panelboard to motor. Overcurrent protective devices protect the motor, controls, and wires against any overloads caused by grounds or shorts. The means of disconnection separates motor and controls from electricity source when adjustment, maintenance, or repair work is being done. The controller starts, stops, and reverses the motor. Motor running protection is provided by overcurrent protective devices which protect motor, controls, and wires against damage caused other than by grounds and shorts.

The circuit conductors may be feeding current to a motor of less than 1 hp. or to one with hp in the hundreds. The type of insulation used will depend on moisture and temperature conditions, and also on the danger of mechanical injury. The size of conductor will be determined on the basis of 125 percent of the full-load current of the motor. Table 7-1 gives you an idea of the wire size for a given motor hp and a given voltage.

The disconnecting means for most motors is either a motor circuit switch or an air circuit breaker. It must be located within 50 ft of and visible from the motor, and must be equipped with a device for locking in OFF position. In every case the disconnecting device must be one which opens all ungrounded conductors instantly. It may also open the grounded wire, provided that it opens all wires simultaneously. It must disconnect both motor and controller, and may be installed in the same case with the controller.

For portable motors, the attachment plug and receptacle are sufficient means for disconnection. For stationary motors of 1/8 hp or less, the branch circuit overcurrent device is sufficient.

Motor controllers may be manual or automatic. For smaller motors a general-use switch or circuit breaker may be used. For larger motors and three-phase motors, automatic controllers give better service. An automatic controllers can be remotely controlled by push-button, and for machinery motors the push-button can be installed convenient to the operator's station. This type of connection can also be used to interlock different motors, as in a system of conveyor belts. Figure 7-27 shows an interlocking system for three motors. Motor 1 must be running before motor 2 can be started, and motor 2 must be running before motor 3 can be started.

Overcurrent protection devices may be fuses or circuit breakers, used to protect the conductors against overloads of current greater than normal starting current. These devices also protect the motor controller, which cannot handle amperage higher than what is normal for the motor.

If fuses are used, one must be placed in each ungrounded wire of sufficient ampacity to allow for motor starting current. A device other than a fuse must be capable of opening all ungrounded wires feeding a circuit.

MOTOR overload protection is required to protect against overload caused other than by a short or ground in the motor branch circuit. After a motor has come up to full speed, and is operating at its normal rated amperage, the equipment driven by the motor, because of a temporary overload or some other cause, may require more power than the rated hp of the motor. To deliver this extra power, the motor must consume greater-than-normal amperage. This type of overload can be safely carried for a short interval, but if it continues too long the motor will be damaged.

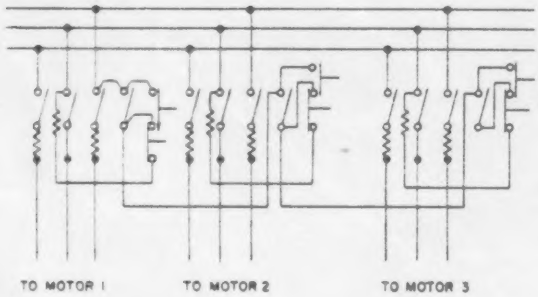
For example: suppose something causes a fuse in a three-phase circuit to blow. The motor will try to continue running on a single phase. This will cause a much higher than normal amperage to flow through conductors and controller. However, a motor current protection device in the motor or controller will open all conductors to the motor.

Automatic controllers have such a device built into the controller. Some small motors have overload devices built into the motor.

Table 7-1.—Circuit conductor wire sizes for various motors.

Motor HP	Single-phase amps at 110 volts	Wire size	Amps at 220 V	Wire size	3-phase amps at 220 V	Wire size
3/4	14	12	6.9	14		
1	16	12	8	14	3.5	14
1 1/2	20	10	10	14	5	14
2			12	14	6.5	14
5			28	8	15	12
7 1/2			40	6	22	10
10					27	8
15					40	6

73.241



73.31

Figure 7-27.—Interlocking controls for three motors.

REPAIRS AND MAINTENANCE

Practically all trouble calls on an interior wiring system involve shorts, grounds, or open circuits. A short circuit is probably the most frequent cause of trouble. When current is not reaching a point where it is needed, an open circuit is indicated. A blown fuse usually means a short or ground, although it may have been caused by overloading a circuit.

WIRING SYSTEM REPAIRS

As mentioned previously, failure of current to reach a point in a circuit means an open in the circuit. This is usually the easiest type of trouble to locate. With your voltage tester start at the last place where you get an indication of voltage. Usually a check of a few points will show where the line is open. The cause will frequently turn out to be a poorly made or poorly soldered joint.

Review the section of troubleshooting fused circuits in Chapter 5 for the procedures in detecting grounds and shorts.

INTERIOR WIRE SPLICES

The way you splice or join conductors together is one indication of your competency as an electrician. An electrical system is only as good as its worst splice. A good splice must have the same mechanical strength and electrical conductivity as the wires it joins together. A spliced wire must be as good a conductor as a continuous conductor.

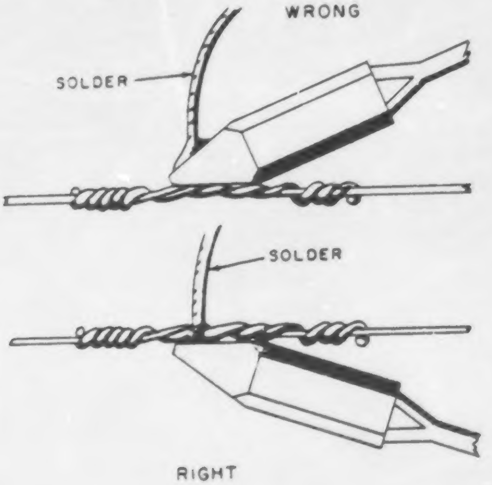
The best wiring practice is to run continuous wires from the service box to the outlets. UNDER NO CONDITIONS SHOULD SPLICES BE PULLED THROUGH CONDUIT. SPLICES MUST BE PLACED IN APPROPRIATE ELECTRICAL BOXES.

The following observations apply to electrical soldering.

1. Soldering a splice helps to protect it from corrosion.
2. Rosin is the only flux used in soldering electrical connections.
3. You can use either a soldering copper or a direct flame to sweat the solder to a splice. Small-sized wire is best soldered with a copper. Large-size requires a blowtorch or an alcohol torch.

Always remember in soldering that you will never get the solder to stick unless and until the splice itself is hot enough to melt the solder. When you apply the soldering copper to the splice, allow enough time for the splice to heat up before you apply the solder itself. To determine when the splice is hot enough, however, hold the solder to the side of the splice OPPOSITE the soldering copper. When the solder melts, the splice is hot enough, and the solder will then flow into every crack and hidden space.

Figure 7-28 shows wrong and right ways of soldering a splice.



73.261

Figure 7-28.—Right and wrong ways of soldering a splice.

Refer to Chapter 7, Basic Electricity, NavPers 10068-B, and to Basic Handtools, NavPers 10085 for further information regarding soldering and splicing.

MINOR REPAIRS TO LIGHTING FIXTURES

Trouble in lighting fixtures is a common problem, especially in fluorescent lighting fixtures, but a knowledge of the principle of this type of fixture makes the job of trouble-shooting a lot easier.

If you are having trouble with fluorescent lamps, check the voltage on this particular circuit. Fluorescent lamps are made to operate on a very small variation in voltage. Check the sockets also, as they may come loose and spread apart, so as not to permit the contacts to make a good connection. Figure 7-29 shows typical fluorescent circuits.

With incandescent lighting most of the trouble is caused by bad sockets or bad wiring in the fixture. Loose lamps in the socket will cause arcing, especially with the larger lamps. A pitted surface on the center contact of the socket prevents a good contact.

A maintenance chart for fluorescent and incandescent lighting will prove helpful in locating trouble (Table 7-2).

APPLIANCE REPAIRS

Although most repairs related to appliances will require removing and taking to the shop, some minor repairs can be done on the premises.

Check first for loose connections. In an electric range, a loose wire could be touching the frame of the range and this could cause a fuse to burn out. With a refrigerator, there is very little that can be done except to check the cord and attachment plug, as most of these appliances have a sealed unit, with the motor and compressor sealed up in a container.

For small appliances, always check the cord and plug first, unless trouble elsewhere is obvious on inspection.

In repairing or servicing electric water heaters, it is always best to work in conjunction with a Utilitiesman. In this and many other trouble calls you will probably have to change the element, and if the element is of the immersion type, you will have to drain all water from the tank before removing the element. Some water heaters have a wrap-around element, and this type can be removed from the inspection doors without opening the tank. When removing this type, always pull a line around the tank as you remove the faulty element, so that you can use the same line to pull in the new one.

SAFETY PRECAUTIONS

Electrical safety is an all hands job. However, every CE must understand that every electrical device which he handles carelessly can cause death to himself or to others. The CE must never let familiarity with his work lessen the habitual determination to be careful and, by that means, to stay alive.

If the CE does not know the safe way to do his work, it will pay him to find out. This requires using PRECAUTION constantly—taking measures BEFOREHAND to ward off accident, or to secure success without harm to himself of others.

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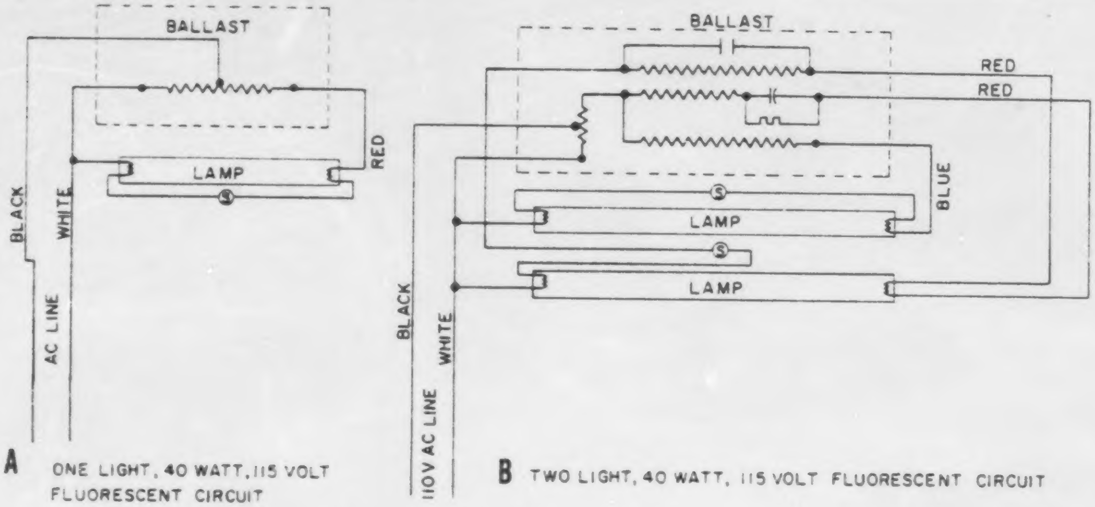
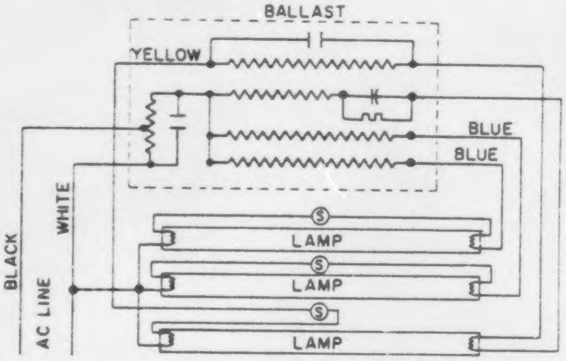

BALLAST
LAMP
RED
BLACK
WHITE
AC LINE
BALLAST
RED
RED
BLUE
LAMP
LAMP
BLACK
WHITE
110V AC LINE

A ONE LIGHT, 40 WATT, 115 VOLT FLUORESCENT CIRCUIT

B TWO LIGHT, 40 WATT, 115 VOLT FLUORESCENT CIRCUIT


BALLAST
YELLOW
BLUE
BLUE
WHITE
BLACK
AC LINE
LAMP
LAMP
LAMP

C THREE LIGHT, 40 WATT, 115 VOLT FLUORESCENT CIRCUIT

73.35

Figure 7-29.—Representative fluorescent circuits.

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Table 7-2.—Lighting maintenance chart.

Incandescent

Symptom	Possible Cause	Remedy
Lamp out, but not defective	Loose lamp, or loose or broken connections.	Tighten in socket, or secure terminals, or repair wiring.
Lamp burns dim	Low voltage.	Match lamp rating to line voltage. Increase line voltage.
Short lamp life	High voltage, or bulb cracked, or incorrect lamp, or excessive vibration.	Match lamp rating to line voltage and reduce voltage. Replace lamp. Replace with lamp of proper rating. Use shock-absorbing device.
Lamp breakage	Water contacts lamp bulb, or bulb touches luminaire.	Use inclosed, vaportight luminaire if water vapor is present. Seal joint where conduit stem enters luminaire. Use correct-size lamp. Straighten socket.

Fluorescent

Symptom	Possible Cause	Remedy
Lamp does not start or flashes on and off. Note: A flashing lamp usually indicates end of lamp life.	Lamp pins not contacting, or lamp worn out, or starter defective, or low line voltage, or fault in circuit of luminaire.	Seat lamp firmly and correctly. Replace with tested lamp. Replace with tested starter. Check with voltmeter. Check wiring and lamp holders. Check ballast.
Lamp flickers; arc wiggles, swirls or flutters	Defect which occurs in both new and old lamps.	Turn luminaire on and off several times. Allow a new lamp to operate a few hours for seasoning. Remove lamp and shake one end down. Replace lamp if flicker persists. If flicker is repeated in new lamp, replace starter
Lamp starts slowly (should start in a few seconds)	Low line voltage or slow starter.	Check with voltmeter. Replace starter.
Short lamp life (A few early failures do not indicate average for group. Some fail after a few hundred hours; others last 4000-6000 hrs.)	Low line voltage, or lamps turned on and off too often.	Check with voltmeter.
Radio interference	May originate from other source—radio too close to lamp—aerial lead-in not shielded.	Operate radio with fluorescent lamps turned off. Move radio 9 to 10 ft from lamp. Shield lead-in and ground shield. Install filter radio or luminaire.
Noise from ballast. (Don't expect perfect silence)		If quiet necessary, take special precautions in locating ballast. If unit very noisy, replace ballast.

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CHAPTER 8

CENTRAL POWER STATION OPERATION

Electrical power throughout the world has become so widespread and reliable, we almost take it for granted. Failure of commercial power can cause severe hardships. Remember the "blackout" that occurred in the mid-1960s? A large portion of the northeastern part of the United States remained without power for an uncomfortable amount of time.

You can recognize the importance, therefore, of being able to produce electric power locally. In military operations, your ability to produce electricity is frequently an absolute necessity. How do we produce this power? One method is to use engine generators.

In this chapter, we will discuss the installation, operation, and components of a variety of engine generators. Upon completion of this chapter, and under the guidance of senior petty officers, you should be able to install, operate, maintain, and troubleshoot equipment efficiently and safely.

INSTALLING CENTRAL POWER STATION

The central point of a power distribution system is the generating station. For an advanced base (temporary base located in or near forward areas outside the Zone of the Interior, the primary mission of which is to support military operations of the Armed Forces), the generators must be rugged enough to take the effects of rain, snow, or other severe weather conditions. They must also be portable, to permit changes in location which may be necessitated by a variety of circumstances.

An advanced base generator set is built as a complete unit which includes, besides the generator itself, the prime mover and switchboard. Such a unit can be installed rapidly at a point where power is needed. However, it is advisable to establish a larger central generating station, capable of producing more power, as soon as possible. A central power station usually includes two main generators and one reserve or emergency unit.

The initial generation and distribution system usually provided for use at an advanced base is 120/240-volt, 3-phase, 4-wire grounded neutral. For replacement a 2400/4160-volt, 3-phase, 4-wire generation and distribution system is used. This system employs 2400/4160-volt, 4-wire, grounded neutral generators in banks of two or more in parallel.

There are three things in particular which must be given careful attention when a power station is to be installed. They are vibration, ventilation, and grounding.

Vibration must be kept to a minimum, which means that generator foundations must be level and based on firm support. If time permits, a poured concrete foundation is best. A level and firmly supported wood platform is next best. Make sure in any case that the foundation is level, and that the generator is level on the foundation. If the generator is not directly connected to the prime mover, a flexible coupling (similar to the "universal joint" on an automobile drive shaft) between generator shaft and prime-mover shaft will accommodate any slight misalignment of the shafts.

The location must be dry and well ventilated, to prevent deterioration of insulation from dampness. Make sure that there is sufficient working space around equipment to permit convenient and safe maintenance work.

The frame of a generator with a terminal voltage of more than 150 volts should be grounded. The grounding system for a generator station should have a resistance of less than 1 ohm. No live parts of the unit should be left exposed.

The generator voltage output is controlled at the switchboard. It is first delivered to the bus bars (bus bars are explained later in this chapter), and distributed from there to the feeder lines. All of this system should be carefully inspected after the plant has been installed and BEFORE it is put into operation.

Cleanliness, as mentioned in a previous chapter, is vital. When oiling bearings, be sure no oil is spilled. Oil in the windings can cause serious damage.

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A visual inspection should be made for loose or broken electrical connections, or loose bolts or screws. If there is any doubt about a wiring connection, recheck against the wiring diagrams contained in the manufacturer's manuals.

Before the plant is put into operation check all electrical connections to ensure that they agree with diagrams and ascertain that collector rings are clean and polished. Then, check all brushes for location, and ensure that they do not stick in the brush holders. Verify brush pressure to ensure that it agrees with that recommended in operational manuals.

In most cases, generators supplying power to feeder lines are of the 3-phase type. Only very small portable units are single phase, for the initial 120/240-volt generator which is installed first and replaced by the central plant, a concrete foundation is not necessary. However, such a generator must have a firm foundation, and must be protected from the weather as much as possible.

CONTROL PANELS

Every generator set at an advanced base must have a control panel. This may or may not be a built-in part of the unit. The size of the panel and the number and type of controls mounted thereon will depend on the size of the generator unit and the type of equipment for which the station must supply power.

A generator must be set up immediately when an advanced base is first occupied, to provide power for temporary lighting, communications, and other services as needed. If the base is to be a permanent one, a central power station must be established for control and distribution of electric power to all spaces and services which are to be located at the base.

For an initial, temporary unit the panel or control board contains all the necessary meters, switches, and other devices. For a permanent central power station with two main generators, the control panel is a combination of two boards, one for each main generator unit. This assembly is known as 'switchgear."

Figure 8-1 shows the control panel for a temporary single-generator unit. Figure 8-2 shows the control board of a single generator in a central power station. Figure 8-3 shows the switchgear unit for a central power station containing two diesel-electric plants.

A study of these three illustrations will show that there is a considerable difference between the instruments shown in figure 8-1 and those shown in figure 8-2. However, you can see that each of the two panels shown to the right in figure 8-3 is identical with the panel shown in figure 8-2. To the left in figure 8-3, however, there is a panel carrying meters and switches common to the two generators in the unit.

In the control panel shown in figure 8-1 there are 18 identified devices. Eight of these relate to the prime mover. The installation, operation, and maintenance of the prime mover are not responsibilities of the CE, but you should understand the purposes of control board devices used for those ends. Operating the unit becomes easy if you know the part each meter and control plays.

The STARTER SWITCH controls the starting motor. Pushing the starter switch completes the circuit between the battery and the starting motor.

The THROTTLE normally controls the amount of fuel fed into the cylinders of the engine and therefore controls the speed of the engine. Most of the advanced base generating units are equipped with a GOVERNOR. The governor is an automatic throttle that maintains a constant engine speed by counteracting changes in load. Thus, the frequency output of the generator is kept constant.

The AIR-HEATER SWITCH controls the current to an ignition system in the air-heater unit installed in the engine. The air-heater unit preheats the ingoing charge of air to the cylinders. This unit is used only for cold-weather starting. The air-heater switch is turned off after the engine has started. It is common practice to preheat the large Diesel engines for cold-weather starting. Several methods exist. One is described below.

The AIR-HEATER PUMP is used in conjunction with the air-heater switch. Operating this pump causes oil to flow under pressure from the air-heater unit spray nozzle. The ignition system in the air-heater unit ignites the oil spray. The heat from this miniature oil burner warms the ingoing charge of air.

The ELAPSED-TIME METER indicates the number of hours the engine is in operation. You will record the reading of the elapsed-time meter in the log. It is used to determine when the engine is ready for maintenance or lubrication.

The OIL-PRESSURE GAGE indicates the engine oil pressure. A quick look at this gage tells you the condition of your lubricating system. The normal operating pressure averages about 30 pounds per square inch.

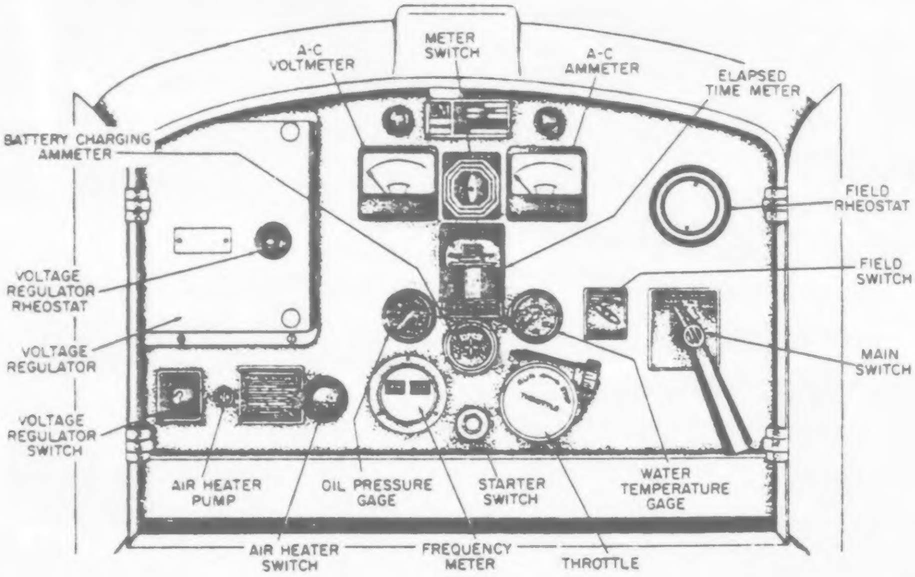
A-C VOLTMETER
METER SWITCH
A-C AMMETER
ELAPSED TIME METER
BATTERY CHARGING AMMETER
FIELD RHEOSTAT
FIELD SWITCH
VOLTAGE REGULATOR RHEOSTAT
VOLTAGE REGULATOR
MAIN SWITCH
VOLTAGE REGULATOR SWITCH
AIR HEATER PUMP
OIL PRESSURE GAGE
STARTER SWITCH
WATER TEMPERATURE GAGE
AIR HEATER SWITCH
FREQUENCY METER
THROTTLE

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Figure 8-1.—Control panel for single diesel-driven generator unit.

The WATER-TEMPERATURE GAGE indicates the temperature of the cooling water in the engine. The water temperature should read 160-185°F under normal operation of nonpressurized systems.

The BATTERY-CHARGING AMMETER indicates the amount of current sent over to the battery from the charging generator. It also indicates the amount of current being delivered by the battery on discharge.

The FIELD SWITCH controls the output of the exciter. In the OFF position, the switch disconnects the exciter field from the exciter armature. In the ON position, the exciter field is connected to the exciter armature. Since the exciter supplies current to the alternator-field coils, the field switch also controls the alternator output. Before the engine is stopped, the field switch is thrown to the OFF position. This action disconnects the exciter field and at the same time shunts a FIELD-DISCHARGE RESISTOR across the exciter-field coils. The field-discharge resistor absorbs any high voltages which might result from the quick opening of the field circuit.

The FIELD RHEOSTAT is a manually controlled variable resistor that is placed in series with the exciter field. It controls the voltage output of the exciter. The value of the exciter voltage determines the amount of exciter current flowing in the alternator field coils. The amount of exciter current, in turn, controls the voltage output of the alternator. Thus, when you adjust the field rheostat, the result is seen as an increase or decrease of the voltage output of your generator unit.

The VOLTAGE REGULATOR also serves to control the voltage. It makes your generator watch an easy job. Without the voltage regulator it would be necessary for you to change the field-rheostat setting each time the output voltage of your generator unit varied from its normal value. The voltage regulator does this for you automatically. Like the field rheostat, the voltage regulator is a variable resistance in series with the exciter field. The resistance is varied automatically by a control unit. The control unit takes changes in generator voltage and converts them to changes in mechanical motion. The changes in mechanical motion will increase or decrease the voltage regulator resistance. In this manner the output of your generator is kept at a constant value.

The VOLTAGE-REGULATOR SWITCH in the ON position puts the voltage-regulator unit to work. With the switch in the OFF position you

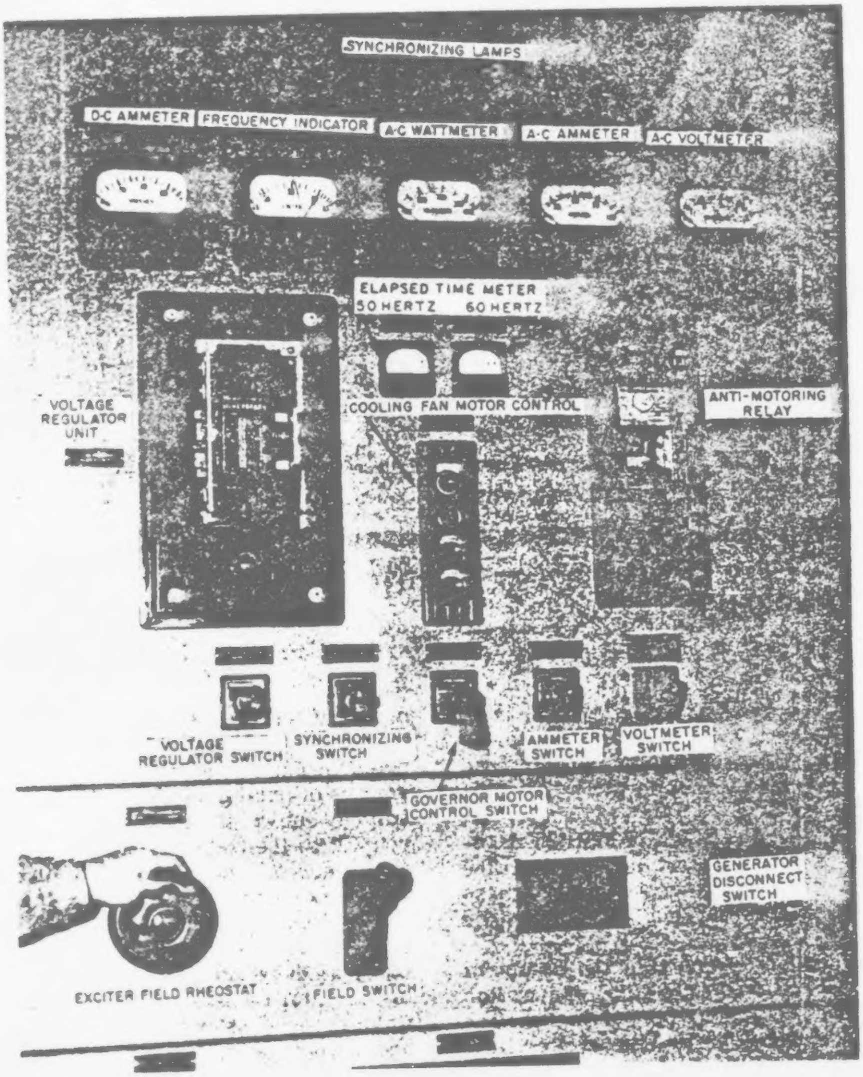
SYNCHRONIZING LAMPS
D-C AMMETER
FREQUENCY INDICATOR
A-C WATTMETER
A-C AMMETER
A-C VOLTMETER
ELAPSED TIME METER
50 HERTZ
60 HERTZ
VOLTAGE REGULATOR UNIT
COOLING FAN MOTOR CONTROL
ANTI-MOTORING RELAY
VOLTAGE REGULATOR SWITCH
SYNCHRONIZING SWITCH
AMMETER SWITCH
VOLTMETER SWITCH
GOVERNOR MOTOR CONTROL SWITCH
GENERATOR DISCONNECT SWITCH
EXCITER FIELD RHEOSTAT
FIELD SWITCH

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Figure 8-2.—Control board of a single generator in a central power plant.

must use the field rheostat to adjust the voltage output of the generator unit.

The VOLTAGE-REGULATOR RHEOSTAT is a small variable resistor mounted on the voltage-regulator unit. It is in operation only when the voltage regulator is in the circuit. The setting of the voltage-regulator rheostat determines the value of voltage kept constant by the voltage regulator.

The A. C. VOLTMETER indicates the voltage output of your generator unit. When you adjust your field rheostat or voltage-regulator rheostat you will be watching the a. c. voltmeter. It will tell you when you have reached the generator's rated voltage output.

The A. C. AMMETER indicates the current output of your generator unit. Any overload or

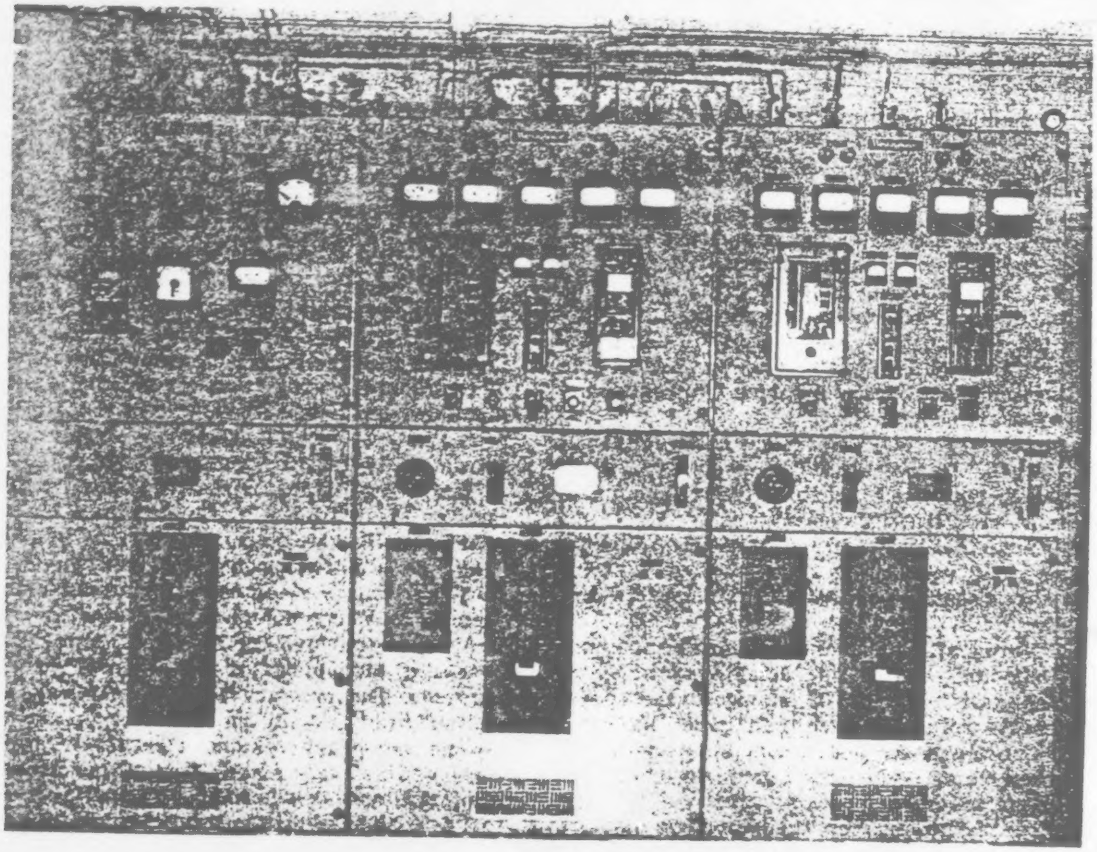

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Figure 8-3.—Switchgear unit for central power station.

unbalancing of a line can be spotted with this instrument.

The METER SWITCH is necessary because this particular unit is a three-phase generator. Each position of the switch puts the a. c. voltmeter and the a. c. ammeter in a different leg of the three-phase line. Thus you are able to read the voltage across any two legs and the current in any one leg. The OFF position of the switch disconnects the ammeter and voltmeter completely.

The FREQUENCY METER measures the frequency (hertz) of the voltage generated by the alternator.

The SYNCHRONIZING LAMPS are used when the generator unit is being paralleled with another generator.

The SYNCHRONIZING-LAMP SWITCH controls the synchronizing circuit.

The MAIN SWITCH opens or closes the circuit between the generator and the load. Remember that it doesn't shut the engine off. In most cases the main switch will have a built-in CIRCUIT-BREAKER. This device will automatically open the main switch whenever a continuous overload current appears on the line.

All of these meters, switches, and controls mounted on the face of a panel board or switchgear unit either control or are controlled by other equipment located behind the board. For example: the output cables from the generator are brought to the back of the switchgear and connected to the line terminals of the main switch. The load terminals of the main switch are connected to the bus bars. These bus bars are bar conductors which serve as collection and distribution points—that is, they receive the power generated by the system, and distribute the same to the distribution circuits leading to the various points of consumption.

At least once a year, a check should be made of the switchgear component, with careful attention given to the following factors.

General cleaning of the component parts is essential. The front panels of dead-front switchboards can be wiped off with a dry cloth. A metal-covered switchgear can be opened and inspected for surface cleanliness. Before any work is done on live parts, however, deenergize the switchboard. Wipe all dust from bus bars and insulating material.

Inspect electrical connections and mechanical fastenings. Do not limit this check to a sight inspection, but touch and shake the various parts to make sure that all connections are tight, and all mechanical parts free to function properly. Pay special attention to the bolted joints of the bus bar, because a loose joint can cause overheating.

Examine all meters and instruments mounted on the switchgear panels. Look for cracked or broken glass, or signs of damage to the cases. Adjust the pointer of each instrument, so that it reads zero when the instrument is not energized.

Examine all indicating lamps, to make sure that none are burned out.

Inspect all instrument transformers mounted on the switchboard. To be in good condition, an instrument transformer must have all primary and secondary connections tight, and all grounding connections intact. Potential transformer fuses must make firm contact in their clips.

Check the condition of all rheostat mechanisms. Replace broken or burned-out resistors. If no replacements are available, make temporary repairs by bridging the burned-out sections. Check to see that there is nothing to block the ventilation of rheostats and resistors.

Test the operation of switchgear position-changing mechanisms, such as the lowering and raising mechanisms, and the pullout devices of the circuit breakers used in metal-clad switchgear.

INSTRUMENT TRANSFORMERS

The voltage and currents delivered by a generating system to the bus bars are too high for safe operation of most of the switchboard apparatus, particularly the switchboard instruments. Instrument transformers, therefore, are mounted on the back of the switchboard and connected to the bus bars. Their purpose is to step down the voltages and currents fed to instruments, relays, voltage regulators, and the like. By the use of transformers, switchboard apparatus can be insulated from the high-voltage circuit, yet receive enough power to indicate accurately the voltage, current, and power in the circuit.

Transformers used to reduce high current values to the small values required to operate ammeters, or to operate current coils in other instruments, are called current transformers. Transformers which reduce high voltages to smaller voltages required to operate voltmeters or the potential coils of other instruments are known as "voltage" or "potential" transformers.

Instrument transformers are explained in chapter 15 of Basic Electricity, NavPers 10086-B. To the discussion contained in that chapter, the following may be added.

The primary winding of a current transformer may consist of a few turns around a laminated iron core, or it may, in some cases, consist of the bus bar or cable carrying the line current. The primary winding is always connected in series with the line.

The secondary winding consists of several turns of relatively small wire wound around a laminated core. It is the secondary, of course, that is connected to the ammeter or other instrument or switchboard device. The current rating of the secondary on practically any current transformer is 5 amperes, regardless of the current rating of the primary.

The secondary of a current transformer should never be open-circuited while the primary is energized. An open-circuited current transformer might develop several thousand volts across the secondary, where there would be only a few millivolts (a millivolt is 0.001 volt) if the secondary circuit were closed. This high voltage might well cause severe, even fatal, shock to the operator. It would in any case break down insulation and destroy the transformer. Hence the invariable rule: NEVER OPEN THE SECONDARY OF A CURRENT TRANSFORMER WHEN IT IS CONNECTED IN THE CIRCUIT.

Potential (voltage) transformers have a low current rating. The low side of the transformer is usually wound for 110 volts, and the ratio of turns on one side to turns on the other is determined by the rating of the high-voltage side.

The primary is connected across the voltage source to be measured, and the secondary is connected to the meter or other instrument or device. The current through the potential transformer depends on the burden imposed by the load on the meter or other device. This load is always constant.

The secondary should always be grounded at one terminal, to eliminate static from the measuring instrument, and also to protect personnel. Again there is an important safety precaution: NEVER SHORT-CIRCUIT THE SECONDARY OF A POTENTIAL TRANSFORMER.

BUS BARS

The bus bars through which the power generated at a station is distributed to the distribution lines are solid copper bars or copper tubes, except in portable or temporary units. In these units insulated cables large enough to handle the load are used instead of copper bars or tubes. In a modern metal-clad switchgear assembly the bus bars extend from one switchgear unit to the next. A ground bus extends throughout the switchboard assembly. Access to the main bus is provided at the rear of the switchgear unit.

Various controls have been explained and illustrated in this chapter, but surge protection (protection against lightning) and controls for feeder circuits remain to be mentioned. If your central power station has the newer type of metal-clad switchgear, there will probably be one unit for surge protection in the assembly. This unit will contain a set of main bus bars, capacitors, and lightning arresters. There will also be a feeder circuit unit from which the power is sent out over feeder cables to the point of consumption. This unit will contain a set of main bus bars, a feeder circuit breaker, instrument transformers, and the necessary switches, meters, and relays.

GROUNDING

The metal cabinet in which each power panel is mounted, and the neutral bus in the switchgear unit, must be grounded. However, there are many metal noncurrent-carrying parts of the distribution system that must be grounded as well. It is the custom, therefore, to draw up a grounding plan or system which will ensure that all metal parts (such as the bases and frames of motors and generators, the steel tanks of distribution transformers, switchgear apparatus, and any other metal parts which might permit development of an electrostatic field) are grounded.

Figure 8-4 shows a representative grounding plan. The dotted lines represent grounding cables. The letter "R" denotes the locations of driven ground rods. The letter "A" indicates points at which branch cables are connected to the equipment. Bare stranded copper cable is used throughout the system, with size 1/0 awg used for the main ground and for the branch cables.

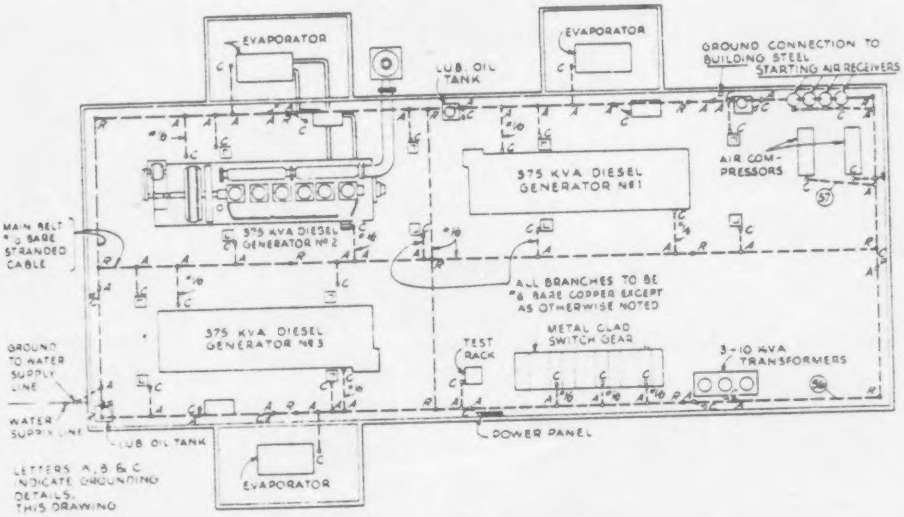
The usual method is to install the preliminary features of the grounding system during the early stages of base construction. Cables must be laid and ground rods driven before the concrete foundations and decks are poured. When the power plant has been installed, the branch cables are connected at one end to the equipment and at the other end to the main belt of cable encircling and running through the station. This main cable is earth-grounded at frequent intervals throughout its run (see letter "R" points in fig. 8-4).

One way to connect branch cables to main cables and the main cables to ground rods is by the use of "ground clamps." However, metal clamps tend to corrode, and corrosion causes high resistance (ground resistance must be less than 1 ohm). To overcome this problem, the metal must be cleaned thoroughly and the connection made very tight. Periodic inspections of the connections must be made to ensure that resistance to ground does not develop.

To eliminate the problem of developing resistance in groundclamp connections, a thermit weld process called the Cadweld process is used on Navy installations. For this type of weld, no outside source of power or heat is required. The equipment used includes a mold which is clamped over ground rod and cable, or over main and branch cables, at the point of connection.

The lower part of this mold has cavities which receive the items to be joined. The upper part has a cavity into which first a metal oxide is poured, and next a starting powder which, upon being ignited, burns at very high temperature.

The starting powder is ignited by a spark from a welder's flint lighter. The resulting reaction in the starting powder melts the metal oxide, which flows from the upper recess in the mold into the lower, cools and hardens there, and thus fuses the items to be connected together.


EVAPORATOR
EVAPORATOR
LUB. OIL TANK
GROUND CONNECTION TO BUILDING STEEL
STARTING AIR RECEIVERS
375 KVA DIESEL GENERATOR Nº 1
AIR COM-PRESSORS
57
MAIN BELT #0 BARE STRANDED CABLE
375 KVA DIESEL GENERATOR Nº 2
#10
#10
ALL BRANCHES TO BE #6 BARE COPPER EXCEPT AS OTHERWISE NOTED
375 KVA DIESEL GENERATOR Nº 3
GROUND TO WATER SUPPLY LINE
TEST RACK
METAL CLAD SWITCH GEAR
3-10 KVA TRANSFORMERS
56
WATER SUPPLY LINE
LUB OIL TANK
POWER PANEL
EVAPORATOR
LETTERS A, B & C INDICATE GROUNDING DETAILS, THIS DRAWING
A
B
C

PLAN OF GROUNDING SYSTEM

SCALE 1/8"=1'-0"

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Figure 8-4.—Representative grounding plan for advanced base power plant.

Because the reaction occurs quickly and with high thermal efficiency, the process is ideally suited for joining copper conductors. Normally the weld is completed 10 seconds after the powder is ignited. This is of great advantage where protection of conductor insulation is a consideration, because in a lengthy heating process the temperature of a considerable length of conductor might be raised high enough to damage insulation.

Figure 8-5 shows Cadweld equipment and material used to weld a ground conductor to a ground rod. A is the mold, B is the clamp which holds the mold in position, C is the cartridge containing the powdered metal oxide and the starting powder, and D is a welder's flint lighter. Figure 8-6 shows some welds made by the Cadweld process.

OPERATION

Once the central power station has been established, the various base activities should be able to count on a continuous and adequate flow of electric current to supply the needs of the living and working spaces. A Construction Electrician who has worked on the installation of the power distribution system will have a good working knowledge of this system as a whole. However, he should also have a thorough understanding of how to operate and maintain the equipment in the power generating station.

A complete knowledge of station equipment can be obtained from three sources which should give you all the information you need to satisfactorily operate and maintain a generating plant. These three sources are: the information on general operating and maintenance procedures given in this chapter, electrical plans and diagrams relating to generators, switch gear, cables, and other equipment, and the instruction manual furnished for each piece of equipment in the plant.

STANDING THE GENERATOR WATCH

Constant, around-the-clock attention must be given to the generators at a central power station that is required to supply a continuous and adequate amount of power. The 24-hour period is divided into a number of watches; the number depends, of course, upon the personnel available for this type of duty.

At most stations, 6-hour watches are the common practice. An 8-hour watch schedule does not ordinarily work a hardship, but any

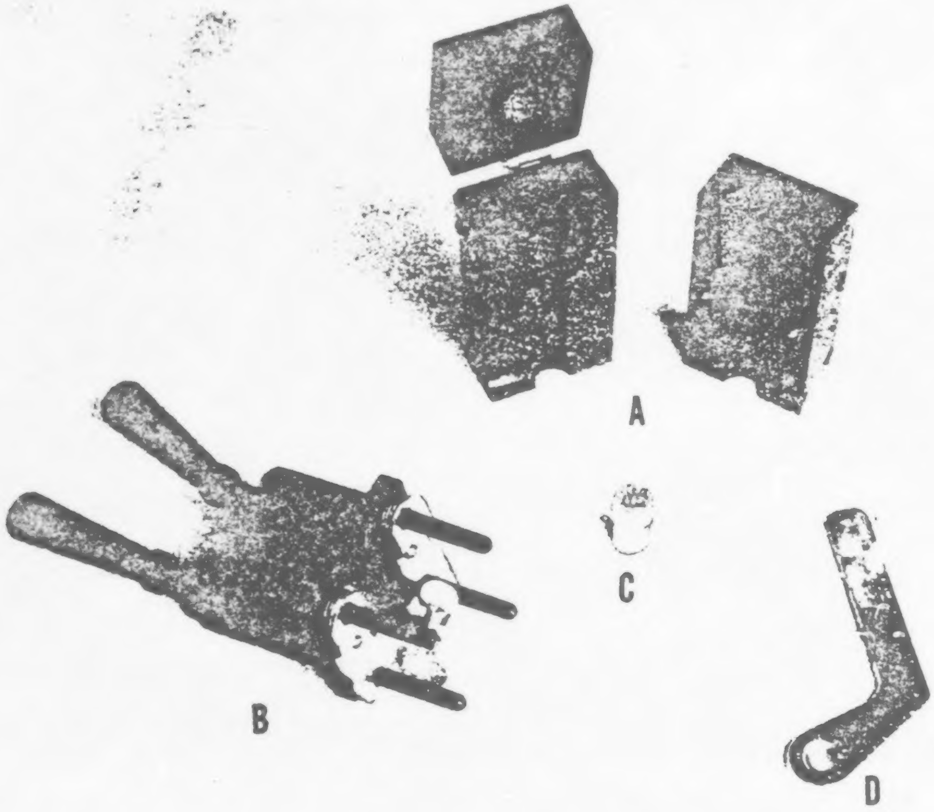

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Figure 8-5.—Equipment and material used for Cadweld process.

watches of more than 8 hours should be avoided unless emergency conditions make them necessary.

MAINTENANCE

To keep the station equipment operating in a satisfactory manner, you must know the system and its operating procedures thoroughly. You must know instantly that an irregularity has occurred, its probable cause, and the quickest and best way to remedy it.

The absolute necessity for keeping spaces in a power station clean and orderly is not always fully realized. This not only protects the equipment, but is also an essential safety measure. Disorder and accident go together. A trip or stumble on trash or clutter in a power station can send you into contact with high voltage and consequent injury or death. Even minor accidents to machinery or injuries to personnel reduce the efficiency of the station and consequently the supply of power to the base.

Keep all tools in proper places when not in use, so you can find the tool you want when you want it, and so that tools out of place will not contribute to disorder and hazard. Keep oily waste in a separate container from clean waste, and reduce fire hazard by disposing of oily waste at least once daily. Keep the floor swept down always, and if oil or grease is spilled, clean it up at once, before it is tracked about, and before someone slips and falls on it. Make sure that all auxiliary equipment is in good condition, and in its proper place, so there will be no delay if it must be brought into emergency service.

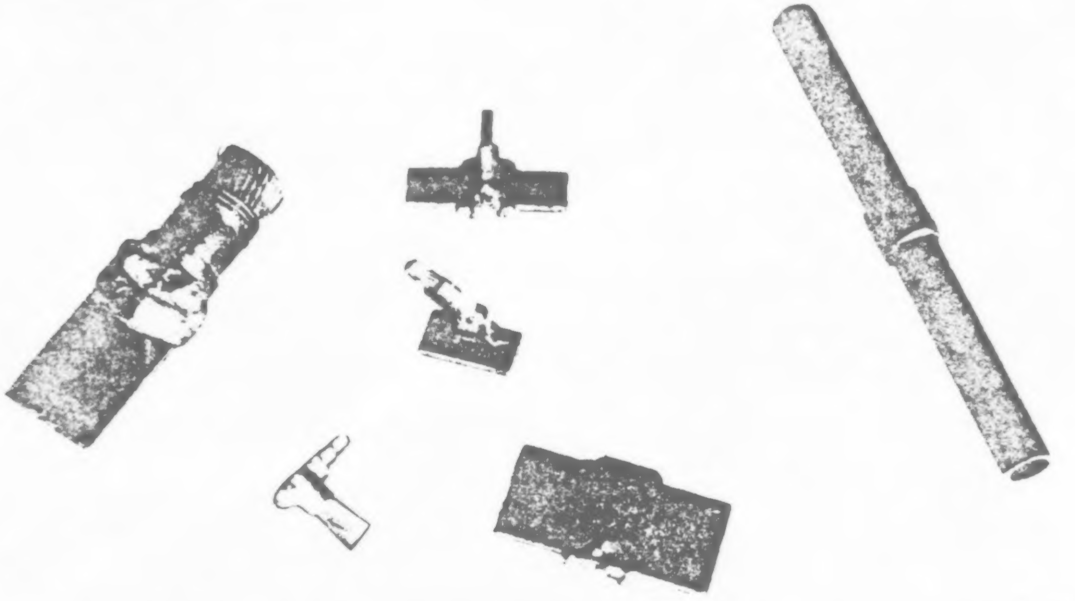

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Figure 8-6.—Welds made by Cadweld process.

The following list of rules should be remembered when you are standing a generator watch. You must not assume, however, that a knowledge of these rules is of itself sufficient. You must follow the general rules and doctrines previously mentioned, and you must also be prepared to act calm and show good sense when unusual situations or circumstances arise.

Allow no unauthorized personnel to loiter about the station.

Allow no unauthorized personnel to go behind any main switchboard.

Make frequent inspections of all running generators.

NEVER replace a blown fuse with a fuse of higher rating.

Never use, or allow to be used, emery cloth, steel wool, or other metallic abrasive near any electrical equipment.

Keep frequent watch on switchboard instruments for any indication of an abnormal condition.

Keep frequency and voltage at correct values. A variation of either will affect, to some extent at least, the operation of electrical equipment on the base, such as teletypewriters or electric clocks. To maintain electric-clock accuracy, an electric clock at the powerhouse should be matched with an accurate nonelectric clock, so that the operator can keep the clocks in time with each other.

Exercise caution before reclosing circuit breakers which have tripped. If the breaker trips again immediately after reclosure, the cause should normally be investigated before a second closure is tried. However, a second closure may be warranted if immediate restoration of power is essential and there is no obvious indication of trouble anywhere. In this connection you should remember that repeated closing and tripping may damage the circuit breaker and thus increase repair and replacement work.

Never start a plant without ensuring that all switches and breakers are open and all external resistance is in the exciter field circuit.

Don't operate generators on continuous overload. It is better to be without power for 15 minutes while you find the cause of the overload and correct it, than to burn up a generator and have no power until it is repaired or replaced. Record the amount and time length of an overload in the log, along with any unusual conditions (such as excessive temperatures) observed.

During your generator watch you may be required to perform a variety of jobs. You may have to start a generator or shut it down. Perhaps you will only have to perform operational maintenance. Let's see what some of these jobs will be.

Before starting, you will verify that the fuel tanks are filled with the appropriate fuel (gasoline or diesel). You will also check the crankcase oil adding any if required. Be sure not to overfill or spill any of the oil. Verify the liquid level in the storage batteries and add distilled water, if necessary. One more check will limit possible damage. Is the radiator filled with water? Has an appropriate amount of antifreeze been added? If these conditions are satisfactory, set the main switch and field switch to OFF positions.

During operation keep checks on the oil, fuel, and water levels and temperature and oil pressure gages. Observe carefully the frequency meter for proper frequency output and the voltages available across each leg of the line. Ask yourself, "Is the charging ammeter for the battery indicating properly? Is the amperage correct in each leg of the line?" Watch for any leaks that may develop.

After shutdown you will be required to clean the machinery, fill the gasoline and diesel fuel tanks, and check the radiator and oil levels.

If equipment vibrates excessively, shut it down, find the cause, and correct it. Record the circumstances in the log.

Keep log sheets up to date (station logs are described in the next section).

Observe all safety rules posted at the station, and any others which are not posted but do apply.

OPERATIONAL LOGS

A station log is a written record which serves a number of purposes. For one thing, it indicates when various equipment units require periodical maintenance work or replacement. A series of entries can often pinpoint signs of breakdown when the breakdown occurs so gradually that it never becomes an obvious problem at any particular instant.

With a great many items of complex equipment working together to produce heat, light, and power for an entire base, it is vital that each item of this equipment be kept operating satisfactorily. A well-kept log is an important means for alerting a trained man to the first signs of threatening trouble.

The form used for log entries varies with the views of the supervisory personnel in different plants, and there is no standard form to be followed by all stations. A CE must familiarize himself with the form used at his particular plant. Regardless of form, any log must describe the hourly performance, not only of the generators, but also of the numerous indicating and controlling devices.

Figure 8-7 shows one type of log that may be kept on the generator units of a power plant. This is only a suggested form, of course, and there may be at your station numerous other items about which it is desired that a record be kept in the log.

STARTING AN A. C. GENERATOR

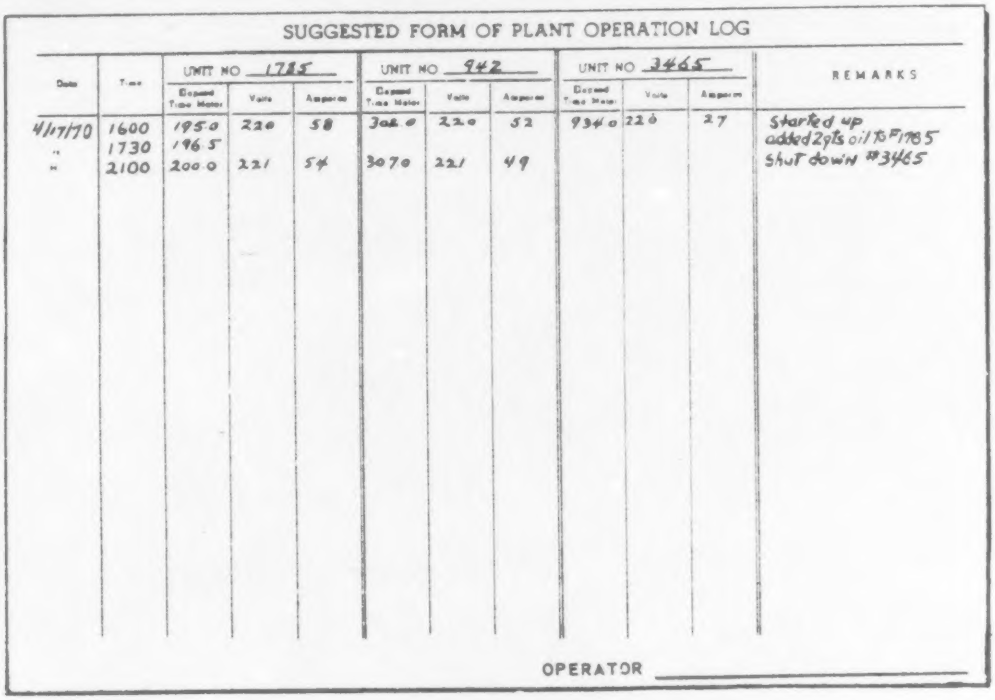
The following description of the steps in starting an a. c. generator is a general description only. For a particular generator you follow step-by-step the instructions for starting given in the manufacturer's manual.

It is assumed that the generator is driven by a diesel engine, and that engine is one which is started by air pressure (many diesels are started by an electric starting motor and batteries or by a gasoline engine which is cut off after the diesel engine starts running on its own fuel).

Figure 8-8 shows the controls and gages on a typical large generator-drive diesel engine. The STARTING AIR lever controls a valve which admits starting compressed air to the engine cylinders. The ENGINE OPERATING lever controls engine speed while starting, stopping, or in an emergency. The SPEED CONTROL knob controls engine speed during normal operation. Figure 8-9 shows details of the engine operating lever.

The speed control lever controls engine speed during normal operation through a governor. In starting, the governor is made inoperative so that the operator can control engine speed during starting by manipulating the engine operating lever. To render the governor inoperative, you set the "pawl-actuating lever" shown in figure 8-9 in the position where it points away from the engine. After the diesel engine starts, you turn the pawl-actuating lever toward the engine.

When starting, you set the engine-operating lever in the "INJ FULL" position shown in figure 8-9 (the pawl-actuating lever, as previously



SUGGESTED FORM OF PLANT OPERATION LOG

Date	Time	UNIT NO 1785			UNIT NO 942			UNIT NO 3465			REMARKS
		Elapsed Time Meter	Volts	Amperes	Elapsed Time Meter	Volts	Amperes	Elapsed Time Meter	Volts	Amperes	
4/17/70	1600	195.0	220	58	302.0	220	52	934.0	220	27	Started up
"	1730	196.5									added 2 qts oil to #1785
"	2100	200.0	221	54	307.0	221	49				Shut down #3465

OPERATOR ____________

73.57

Figure 8-7.—Representative generating station operator log.

stated, is set away from the engine at this time). After the diesel engine starts, you turn the pawl-actuating lever toward the engine and set the engine-operating lever in the "GOV RUN" position shown in figure 8-9. Engine speed is now controlled by the governor.

The "latch lever" shown in figure 8-9 releases (by squeezing) the engine-operating lever for movement to a different position, and locks the same in the new position when the latch lever is released.

The "vernier knob" shown in figure 8-9 is used to control speed adjustment when you are operating the engine under manual speed control, as in an emergency.

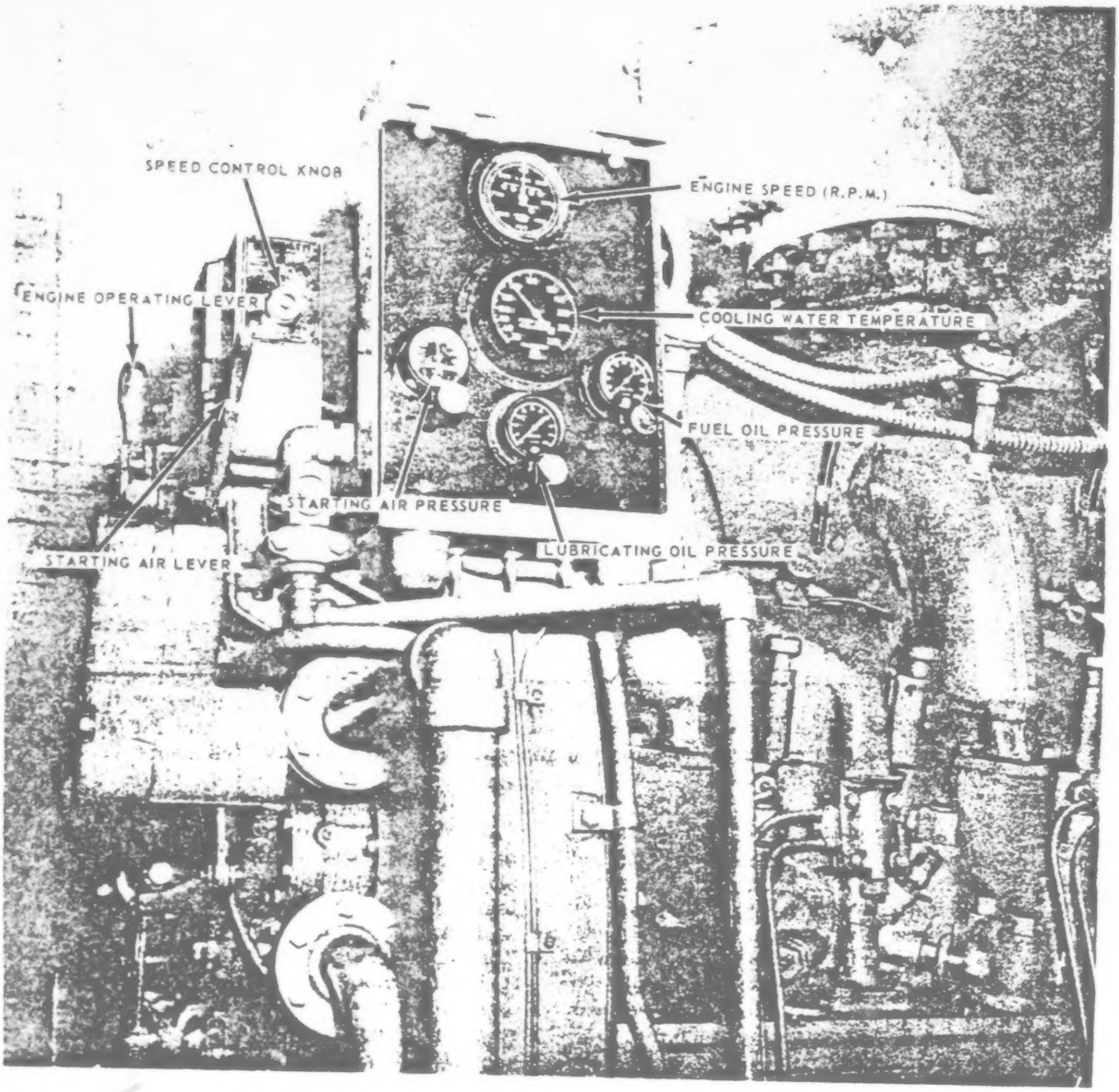
Before you start the diesel engine, ascertain that the circuit breaker and the field switch on the generator switchboard are in the OFF position. After you have verified that no load exists on the generator, you set the pawl-actuating lever for manual control (away from the engine), and latch the engine-operating lever in the "INJ FULL" position shown in figure 8-9.

Pull down on the starting air lever (fig. 8-8). This will admit air to the cylinders, which will in turn set the pistons in motion. The engine should fire within 10 seconds; when it does, release the starting air lever.

Immediately after the engine fires, check the "lubricating oil pressure gage" shown in figure 8-8. If it does not indicate oil pressure within 10 seconds after the engine fires, stop the engine at once by moving the engine-operating lever to the "INJ STOP" position (fig. 8-9).

If lubricating oil pressure is satisfactory, turn the pawl-actuating lever toward the engine and move the engine-operating lever to the "GOV RUN" position. Engine speed is now being controlled by the governor.

You will have previously ascertained the engine speed required to maintain the required voltage output. Assume that to produce a 60-hertz voltage, the engine must make 600 rpm. Check the rpm indicator and if it does not read 600 rpm, turn the "speed control knob" in the appropriate direction until the engine speed indicator reads 600 rpm.


SPEED CONTROL KNOB
ENGINE SPEED (R.P.M.)
ENGINE OPERATING LEVER
COOLING WATER TEMPERATURE
FUEL OIL PRESSURE
STARTING AIR PRESSURE
LUBRICATING OIL PRESSURE
STARTING AIR LEVER

73.58

Figure 8-8.—Diesel engine, showing controls and gages.

Recheck the lubricating oil gage for proper oil pressure, the "fuel oil pressure" gage for proper fuel oil pressure, and the "cooling water temperature" gage for proper water temperature (fig. 8-5).

SWITCHBOARD CONTROLS

This generator is now running, but it is not yet "on the line"—that is, not yet sending power out into the distribution line. Before discussing

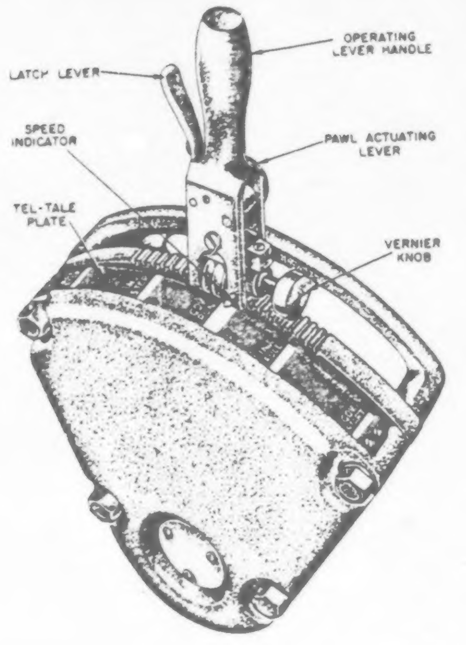


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Figure 8-9.—View of diesel engine operating lever, showing details.

the method of putting the generator on the line, some mention of the switchboard instruments and controls is necessary.

The switchboard instruments should include an indicating wattmeter to avoid the necessity for making numerous ammeter and voltmeter readings to compute power output. If records must be kept on generator efficiency, a watt-hour meter is also needed.

Remember that the voltmeter measures the voltage of the bus, not that of any one generator contributing to the bus voltage. Ammeters, however, should be connected in series with at least one lead of the output of each generator. If only a single ammeter is available for measuring three-phase current, it must be switched to the different phases.

A group of lamps connected across the bus, and with a center point grounded, provides a practical means for detecting any accidental ground.

PLACING GENERATOR ON THE LINE

Before you set about putting the generator on the line, make sure that you know the locations of the various switchboard controls, and that you are able to operate them smoothly and in proper sequence; check to see that the voltage regulator switch is in OFF (or MANUAL CONTROL) position, and that the voltmeter selector switch is set to permit the a. c. voltmeter to indicate the desired measurement.

Turn the handle of the exciter field rheostat counterclockwise as far as it will go, so as to put maximum resistance into the shunt field of the exciter.

Throw the field switch to the ON position, thus making exciter voltage available to the generator field. At the same time watch the a. c. voltmeter and ensure that it records a low reading.

Turn the exciter field rheostat knob down clock-wise, thus decreasing exciter field resistance, and increasing exciter field voltage and excitation current in the generator's field winding. This will cause output voltage to rise. Watch the a. c. voltage meter, and turn the rheostat knob until the rated voltage is reached.

Check the frequency reading on the frequency meter. Increase or decrease the engine speed until you read normal frequency (in this case, 60 hertz).

Turn the voltage regulator switch to the ON or AUTOMATIC position, thus placing the voltage regulator in control. Then check the voltmeter to ensure that it still reads rated voltage value. If the value has changed, adjust the voltage regulator rheostat until the voltmeter again reads rated value.

Release the interlock on the circuit breaker, thus closing the generator circuit and energizing the bus. With the generator now connected to the external circuit, the a. c. ammeter will indicate the current drawn by the load.

Check the current in each phase by switching the ammeter. Recheck the voltage across each phase.

SYNCHRONIZING ALTERNATORS

The load power demand may often reach a point where it cannot be satisfied by a single generator, in which case it becomes necessary to "cut in" another generator—that is, add another generator to the bus. This CANNOT be done simply by starting up the engine of a reserve generator and placing this one on the line by throwing the main switch.

Four very important factors must be taken into account. The incoming generator voltage must equal the bus voltage. It must have the same frequency and must be in phase with the bus voltage. Finally, all phases must be connected in proper sequence.

The procedure called "synchronizing alternators" simply means bringing the incoming generator into correspondence with the bus in all four of these respects.

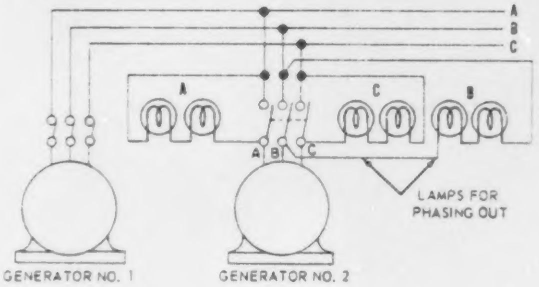
To adjust electrical speed—that is, frequency—you adjust the speed in rpm of the prime mover—in this case, the diesel engine. To bring the incoming generator into phase with the voltage on the bus, you will probably use a system of synchronizing lamps. Watch the voltmeters on the two units until they read the same.

The purpose of synchronizing frequency and speed is to ensure that the difference in potential between CORRESPONDING terminals of the two generators is zero. Synchronization is completed by using lamp methods or a synchroscope.

Lamp Synchronizing Methods

The most satisfactory arrangement for synchronizing lamps to be connected is the two-bright one dark method discussed in Basic Electricity, NavPers 10086-B. Two other methods are used, one is called the "all-dark" method, the other, the "bright-lamp" method.

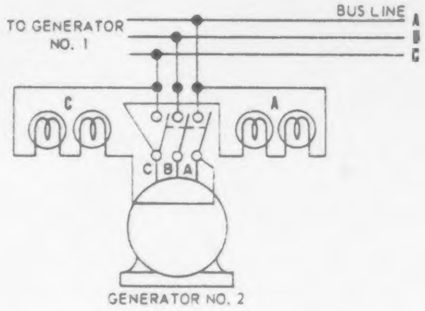
In the all-dark method of synchronizing, lamps are connected across an open three-pole switch between the bus and the incoming generator as shown in figure 8-10. If the lamps increase and decrease in brilliance together, the phase sequences of the two generators are the same. If the lamps rotate in brilliance, the phase sequences are not identical. Interchanging any two of the three leads from the incoming generator will obtain the correct phase sequence. Be sure the lamps have a voltage rating twice the generator terminal voltage. If lamps of this voltage rating are unavailable, several lamps in series, voltage dropping resistors, or step-down transformers must be used. When the lamps are dark the voltages are in phase and the paralleling switch may be closed.



73.60

Figure 8-10.—The all-dark synchronizing method.

The "bright-lamp" method is more sensitive and is used for large, high-speed generators. The arrangement of lamps is shown in figure 8-11. When lamps A and C burn with the same brilliancy the unit is in phase. As one of the two increases in brilliancy and the other decreases, the instant of synchronism is the instant when they match in brilliancy. The sequence of brightness of the lamps indicates whether the incoming alternator is fast or slow. It is standard practice to close the generator switch when the incoming alternator's frequency is slightly ahead of that of the already operating alternator.



73.61

Figure 8-11.—The bright lamp synchronizing method.

Synchronizing With Synchroscope

The sequence of operations in paralleling two alternators by synchroscope follows.

Compare the bus voltmeter reading (voltage produced by alternator already operating) with

888

that on the incoming alternator voltmeter. If they are not the same, adjust the voltage regulator rheostat of the incoming generator until the voltage of that one is equal to the bus voltage. This is an important step, because unequal voltages will cause circulating currents to flow between the parallel generators.

Compare the frequency of the incoming generator with that of the bus, and adjust to correspond by means of the incoming generator's governor motor-control switch.

Turn the synchronizing switch to the ON position. The synchroscope will rotate in one direction or the other. If the switchboard is also equipped with synchronizing lamps, they will increase and decrease in brilliancy.

Use the governor motor control switch to adjust the speed of the incoming generator until it is operating at approximately the same frequency as the bus voltage. This will be indicated by the synchroscope rotating slowly in the FAST direction, and the synchronizing lamps slowly increasing and decreasing in brilliancy.

Ascertain that the voltages of bus and incoming generator are the same. Then, JUST BEFORE the synchroscope pointer passes through the zero position, close the incoming generator's breaker and thus "cut in" the generator. If lamps only are being used, close the breaker JUST BEFORE the midpoint of the dark period of the lamps is reached.

After the incoming generator has been thus "cut in" to the bus, there are two additional adjustments that must be made. One of these ensures that each generator is carrying its share of the kilowatt load. The other ensures that each generator is operating with the same power factor (power factor is explained in Basic Electricity, NavPers 10086-B).

The division of kilowatt load between a. c. generators operating in parallel depends on the relative setting of their engine governors. Equalizing power factor means ensuring that each generator is producing its share of wattless current or "reactive kv-a." The amount of reactive kv-a two generators supply depends on the relative setting of their voltage regulators. Therefore, to adjust the generators for parallel operation you take the following steps.

Turn the governor motor control switches until the wattmeters of the generators read the same (if the generators have the same rating), or until the load is proportionally divided (if the generators have different ratings). The load is increased on a too lightly loaded generator by increasing engine speed, on a too heavily loaded generator by decreasing engine speeds. These adjustments must be made simultaneously, to maintain constant frequency.

To balance reactive load, turn the voltage regulator rheostat of each generator until the power factor meter reading is the same for each, indicating that the burden of reactive kv-a is being properly shared. If the switchboard is not equipped with power factor meters, the a. c. ammeter of each generator can be used. Proper adjustment exists when the ammeters show equal currents for generators of the same rating, or proportionally equal currents for those of different ratings.

The direction in which you turn the voltage regulator rheostat of each generator depends on the reading of the generator's power factor meter or ammeter before the adjustment is made. The voltage should be decreased on the generator carrying too much power factor, increased on the one carrying too little.

After throwing the main switch, observe the a. c. ammeters of equal generating units to ensure that they read the same. Unequal readings mean that one generator is doing more work than the other. You can even out the load by increasing the speed of the generator having the lower ammeter reading. Adjust the speed control knob until both a. c. ammeters read the same.

SECURING GENERATORS

When a SINGLE generator, connected along to a bus, is to be taken out of operation, it is secured in the following manner.

Remove as many individual loads as possible to reduce arcing and damage to the line switch or circuit breakers when the circuit is opened. Open the feeder breakers to further reduce the generator load as much as practicable.

Trip the generator circuit breaker.

Turn the voltage regulator switch to the OFF or MANUAL position.

Turn the handle of the exciter field rheostat counterclockwise, as far as it will go, thus cutting in all resistance to the exciter field and decreasing the voltage to the exciter field.

CAUTION: The field circuit of a generator which is to be disconnected from the bus bars must not be opened before the main switch has been opened. If the field circuit is opened first, a heavy current will flow between the armatures.

Open the field switch slowly. Slow movement of the switch reduces the danger of a high

1237

induced voltage in the field circuit. This, if the field discharge resistors were inoperative, could break down the insulation.

Move the governor control lever to the low idle engine speed and run the engine about 5 minutes until it cools down.

Stop the prime mover, as by moving the engine operating lever shown in figure 8-9 to "GOV STOP" position.

It may be necessary to secure a generator which is operating in parallel with another. The typical situation is one where a peak load (as when darkness falls and many lights come on) occurs and then passes. When the load comes on, another generator is cut in; when it passes, the generator is secured.

Before you remove the generator power from the bus, it is very important that you shift the kilowatt load being carried by the generator which will be cut out to the generator or generators which will remain on the line. This shift of kilowatt load is accomplished by turning the governor motor control switch of the generator to be secured to LOWER, and the same switches on the remaining generators to RAISE. The wattmeters on the switchboard will indicate how the shift is progressing and when it is completed.

When the load has been shifted, trip the circuit breaker on the generator which is to be taken out, and then secure that one as you would a single generator.

A generator which has been operating under a heavy load should not be shut down until it has been run on a light load for a few minutes to reduce temperatures.

ENGINES

Engine generators are necessary in military operations, as we have seen. There are thousands of them in existence, with a variety of shapes, sizes, capacities, reliability, and economy. We will discuss only a few of these so that you will be able to perform your duties intelligently and safely.

GASOLINE ENGINE SETS

Gasoline engines are useful as prime movers for generators. They are also suitable to supply power and light on an intermittent or emergency basis. Their initial cost is much less than that of diesel engines, but maintenance costs are higher and their useful life is short. Nevertheless, they are used frequently by Seabees for emergency purposes or where the power drain is small.

The one cylinder engine driven generator in figure 8-12 is about the simplest you'll find in an advanced base. It will handle loads up to 1.5 kilowatts. A starting rope wrapped around the flywheel is used to start the engine in the same manner as that for small outboard or power lawn motors.

Some gasoline-driven generators used by the Seabees supply as much as 10 kilowatts of a. c. power. These may be used as emergency standbys for a small central power station. They are skid-mounted, and if equipped with weather-proof metal housing, are designed primarily as portable sets for outdoor operation.

Operation

In the gasoline engine, the gasoline and air are mixed together before being admitted to the cylinder in which compression takes place. The intake stroke of the piston sucks air through the air cleaner into the carburetor.

In the carburetor, the clean air is mixed with the vaporized gasoline from the fuel tank. The new mixture continues on through to the intake manifold which is connected to the cylinder head. An intake valve admits the air-gasoline mixture into the cylinder.

In the gasoline engine, a spark is introduced into the cylinder igniting the air-gasoline mixture just as the piston completes its compression stroke. The ignited gases expand and the piston is pushed down into the power stroke. The exhaust stroke of the piston then expels the burned gases out of the cylinder chamber. Sparks are created at appropriate times using a small ignition system as shown in figure 8-13.

The ignition coil delivers a pulse of high voltage through the distributor to the proper spark plug when the coil is interrupted by a set of breaker points. The distributor, which is turned by the engine camshaft, connects the high voltage to the spark plug of each cylinder at the time it is due to be fired. It also opens and closes the breaker points that determine the exact instant each plug fires.

Servicing

You must always check the appropriate instruction manual for specific operating and servicing procedures. The following information,

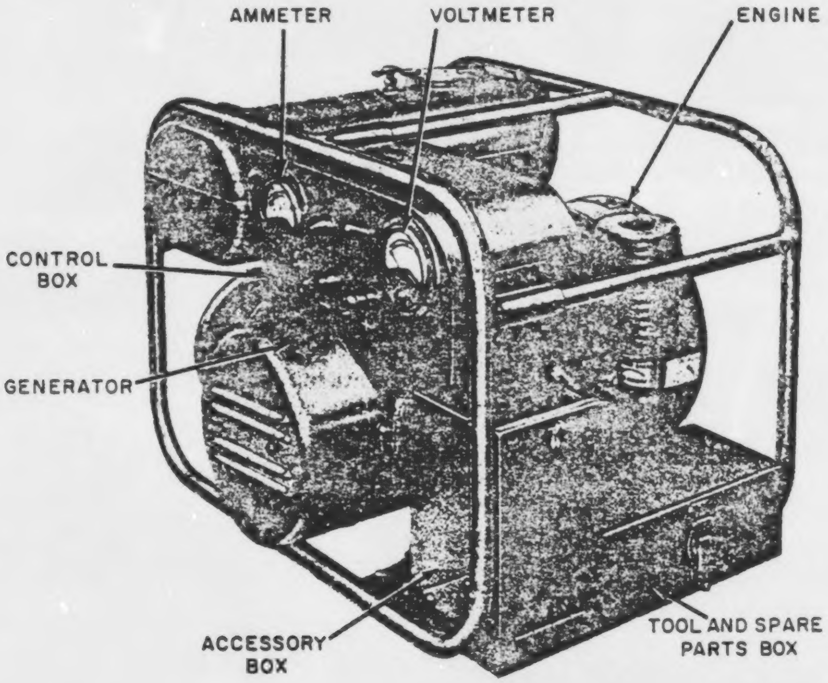


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Figure 8-12.—Gasoline engine generator.

however, is general and applicable to all of the possible generators you will encounter.

Make sure that the fuel you are going to use is not contaminated with dirt or water, and that all equipment (cans, funnels, and/or nozzles) for transferring the fuel to the engine fuel tank is clean. Dirty fuel clogs the carburetor and fuel lines.

Water in the fuel often keeps an engine from starting and damages the injection pumps and nozzles of diesels. In cold weather, especially, fuel tanks should be kept full to minimize condensation of moisture in them.

BE SURE THE FUNNEL IS IN DIRECT CONTACT WITH THE TANK when fuel is being transferred, to eliminate the possibility of an explosion.

Damage due to dirt can be eliminated or minimized by changing the air cleaner at appropriate intervals. If the oil feels gritty when checking its level, change it and the filter too.

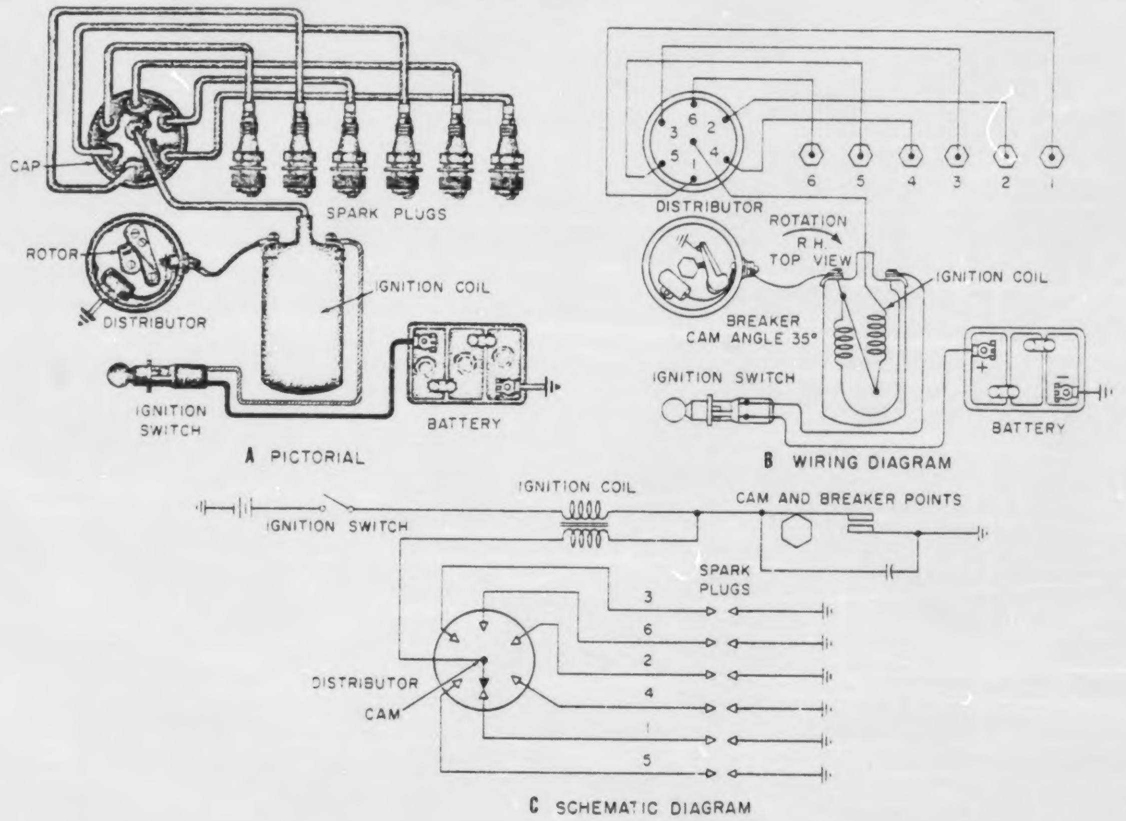
If your generator requires water for its cooling system, be sure to keep it filled. Remember, that in freezing temperatures, antifreeze must be added.

Battery care is a necessity. Check the electrolyte level periodically and add water if required. Distilled water is preferable to plain water, if available. To minimize battery difficulties, coat the battery terminals with a light coating of corrosion-preventive grease after connections have been tightened.

BRUSHLESS GENERATORS

Figure 8-14 shows an elementary circuit diagram for a brushless generator system. Elimination of brushes, slip rings, and commutators is accomplished by placing a rectifier assembly, generator field and exciter armature on the rotor.

In the brush type of a. c. generator (fig. 8-15), the field current is transferred from the rotating part of the machine to the generator field by the use of commutator, brushes and collector

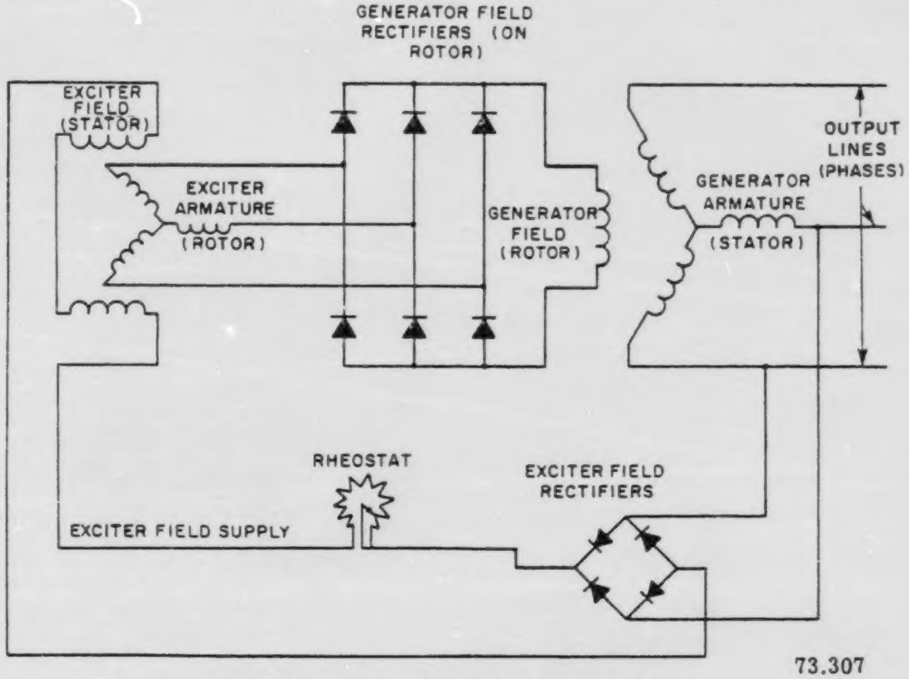

CAP
SPARK PLUGS
ROTOR
DISTRIBUTOR
IGNITION COIL
IGNITION SWITCH
BATTERY
A PICTORIAL
DISTRIBUTOR
6 5 4 3 2 1
3 6 2 5 1 4
ROTATION R.H. TOP VIEW
IGNITION COIL
BREAKER CAM ANGLE 35°
IGNITION SWITCH
BATTERY
B WIRING DIAGRAM
IGNITION COIL
IGNITION SWITCH
CAM AND BREAKER POINTS
SPARK PLUGS
3
6
2
4
1
5
DISTRIBUTOR
CAM
C SCHEMATIC DIAGRAM

65.53

Figure 8-13.—An ignition system.

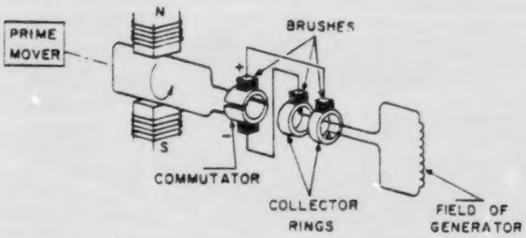
rings. Much time is spent on the maintenance of these components.

Brushless type rotating exciters (fig. 8-16) eliminate the necessity for commutator, collector rings and brushes by applying the a. c. output of the exciter armature to silicon rectifiers connected in a bridge. The d. c. rectified output is then applied directly to the field. Since all these components are mounted on the rotor, no need exists for brushes, commutator or slip rings, making the entire unit compact, simple, and free of sparking. Maintenance is thus reduced. As time goes on, you will see more and more of these generators in the field.


GENERATOR FIELD
RECTIFIERS (ON
ROTOR)
EXCITER
FIELD
(STATOR)
EXCITER
ARMATURE
(ROTOR)
GENERATOR
FIELD
(ROTOR)
OUTPUT
LINES
(PHASES)
GENERATOR
ARMATURE
(STATOR)
RHEOSTAT
EXCITER FIELD
RECTIFIERS
EXCITER FIELD SUPPLY

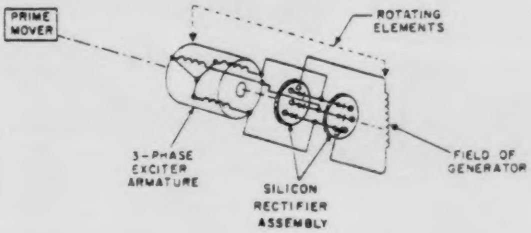
73.307

Figure 8-14.—Basic brushless generator.


PRIME
MOVER
N
S
BRUSHES
+
-
COMMUTATOR
COLLECTOR
RINGS
FIELD OF
GENERATOR

73.308

Figure 8-15.—Brush type rotating exciter.


PRIME
MOVER
ROTATING
ELEMENTS
3-PHASE
EXCITER
ARMATURE
SILICON
RECTIFIER
ASSEMBLY
FIELD OF
GENERATOR

73.309

Figure 8-16.—Brushless type rotating exciter.

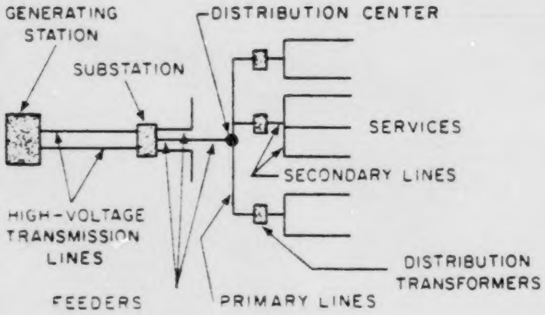
CHAPTER 9

OVERHEAD POWER DISTRIBUTION

Power from the generating plant at an advanced base may be carried to the various points of consumption by overhead transmission and distribution lines, by underground cable, or by a combination of both. At most advanced bases, the high voltage developed at the central power station is usually and preferably distributed by overhead feeder lines. Such lines are cheaper to build, simpler to inspect, and easier to maintain than underground cables. Obviously, use of underground cables is preferred at airports to prevent hazardous flight conditions.

Voltages developed normally range from 110/220 volts to 13,200/13,800 volts in more populous areas such as Okinawa, Adak, Vietnam and Puerto Rico. The initial generation and distribution system at an advanced base is provided by a 110/220 volt, 3-phase, 4-wire grounded neutral. Replacement may then be provided by a 2400/4160 volt, 3-phase, 4-wire grounded neutral supplied by banks of two or more generators. Finally, as requirements increase, power sources capable of providing the larger voltages are installed.

Whether underground or overhead, the distribution system in an advanced base is of the radial type. A representative transmission and distribution system is shown in figure 9-1.



26.77

Figure 9-1.—Transmission and distribution system.

In this chapter, we will discuss various aspects of overhead distribution so that you will be able to perform various assignments of installing, maintaining, and repairing of overhead distribution facilities more effectively.

Upon completion of this chapter, you should be able to describe how to

- erect and climb poles
- install guys, strain insulators, and guy anchors
- mount crossarms and racks
- string and tie conductors
- install transformers safely
- install additional components and protective devices associated with high voltage equipment
- install and troubleshoot various components of street lighting facilities
- perform pole-top resuscitation
- use safety procedures associated with overhead line installation

INSTALLING OVERHEAD LINES

The major stages in constructing an overhead transmission distribution system include the preparation, erection and guying of poles, crossarm mounting, stringing the conductors and adjusting them for proper sag.

In planning an overhead system, arrange the route with the possibility of future development in mind—that is, make it possible to add additional circuits for new buildings and equipment. Consider also the nearness of other electrical circuits or pole lines, and be careful not to place electric light and/or power lines on the same crossarms with communication lines. Remember that any power line below 8700 volts crossing or running above a communication line must have a minimum clearance of 2 ft. About 4 ft is the clearance most commonly used. For voltage higher than 8700 volts the minimum clearance must be 6 ft.

All power lines must be located ABOVE telephone or other communication lines.

PREPARING THE POLE

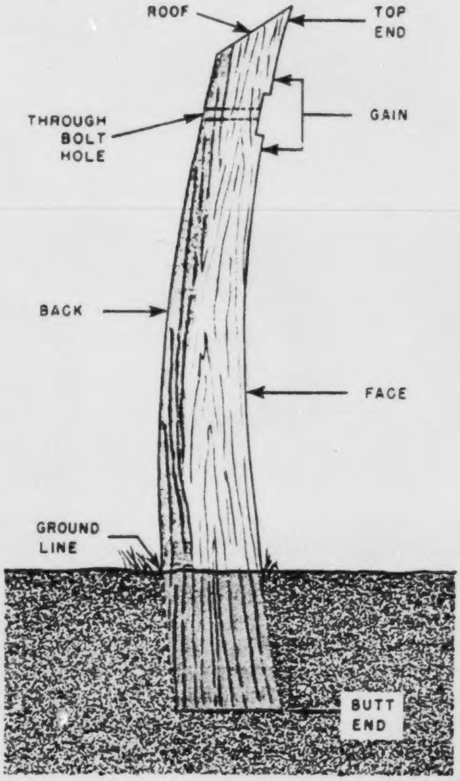
At an advanced base you may have to use standing trees as poles. If this is so, select the straightest trees you can find and trim them.

Trimming consists of cutting branches off flush with the trunk and stripping off all the bark. This procedure, necessary to make the pole safe for a lineman to climb, will often reveal defects in the pole. Flush knots left after branches are trimmed should be painted over, to prevent water penetration of the pole.

Most of the poles you will use will be already trimmed and treated with creosote (to prevent rotting) before they arrive at the site. Creosote is a toxic compound that will blister the skin, so use gloves when handling or climbing such poles. AVOID touching your eyes with such gloves. Be sure to have your sleeves rolled down.

The next step is to cut the "roof" (roof-like cut at the upper end, made by sawing a single slant cut that drains toward the back of the pole) and the "gains" (a gain is a notch in which a crossarm is set). This cutting should be done with the pole in a rack of some kind which will hold one end of the pole above the ground. If the pole is curved, it should be set in the rack so that the curve or sag is toward the ground. Then cut the roof diagonally and the gain or gains on the upper surface, so that the relation of roof to gains is as shown in figure 9-2. Remember that the gain is always cut on the face of the pole, and the face is the inside of any curve the pole may have. Following this rule ensures that the pull of wires on the crossarm will be against the curve of the pole. Remember, too, that the slope of the roof should be parallel to the wire lines, not across them. The reason for this is to ensure that water draining off the roof will run down the back of the pole, and not into the crossarm gains.

The center of the first or top gain should be located 12 in. from the top of the pole. Since the width of the gain is the height of the crossarm, measuring half the height of the crossarm above and below the center of the gain will give you the top and bottom of the gain. The gain should be cut about 1/2 in. deep. It is good practice to make the gain slightly concave, so the crossarm will bear solidly against the outer ends. The spacing between succeeding gains depends on the voltage in the lines. For voltages up to 8700 volts the minimum spacing is 24 in. For voltages from 8700 volts to 50,000 volts the minimum spacing is 48 in.



29.233
Figure 9-2.—The parts of the pole.

The next step is to bore the hole for the crossarm through bolt shown in figure 9-2. The standard through bolt has a diameter of 5/8 in. The diameter of the bolt hole should be 11/16 in. To center the hole, draw intersecting diagonal lines across the gain. If possible, paint all this cut work to prevent decay.

DIGGING POST HOLES

The depth for a pole hole depends on the length of the pole and the composition of the soil. A hole in firm, rocky terrain does not need to be as deep as a hole in soft soil. Table 9-1 gives recommended post-hole depths for poles from 20 to 65 ft long in firm soil and in rock.

Table 9-1.—Depth for setting pole in soil or rock.

Length of pole (ft)	Setting depth (ft)	
	In soil	In rock
20	5.0	3.0
25	5.5	3.5
30	5.5	4.0
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0

73.310

A pole set in sandy or swampy soil must be supported by guys or braces, or by "cribbing." Cribbing means the placement of some firm material around the part of the pole that is below ground. One method of cribbing is to sink an open-bottom barrel in the hole, set up the pole in the barrel, and then fill the space around the base of the pole with concrete or small stones after the pole has been plumbed (brought to the vertical). Another method of cribbing is shown in figure 9-3.

There may be a power-driven hole-digger available, but in the absence of one of these the holes must be dug by handtools (fig. 9-4). You use a "digging bar" to loosen the soil. About the first 2 ft of depth can be removed with a short-handle shovel. Below that you loosen the earth with a long-handle shovel, and haul it up with a long-handle device called a spoon.

A hole should have a diameter about 6 in. larger than that of the base of the pole, to allow room for tamping in backfill. It should be a little larger at the bottom, to allow for plumbing the pole.

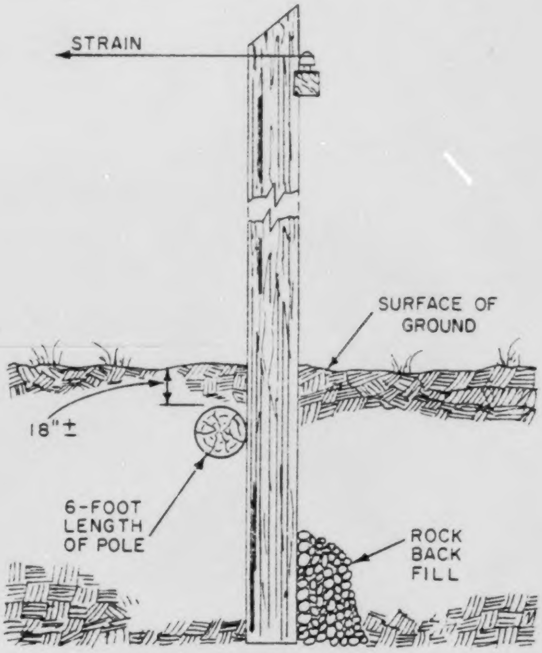


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Figure 9-3.—Cribbing a pole with stone and log.

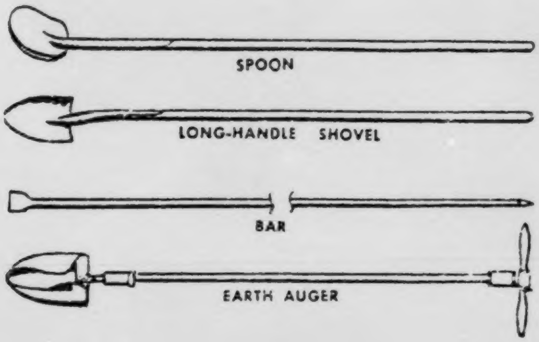

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Figure 9-4.—Digging tools.

ERECTING POLES

If a line truck with winch and A-frame is available, the job of erecting poles is simple. A sling is placed around the approximate midpoint on the pole and the winch heaves it up. The truck then proceeds to the hole, and the base of the pole is guided in as the winch lowers away. Since the butt or base is heavier than the top end, the pole will be raised to an almost vertical position.

In the absence of this equipment, however, the pole must be "piked up"—meaning that the pole is placed with base adjacent to the hole and the upper end supported on either a "mule" or a "jenny." A "jenny" is a wooden support made in the form of an X, while a "mule" is a wooden support made in the form of a Y. The upper end is then "piked" into the air by men using pike poles (fig. 9-5).

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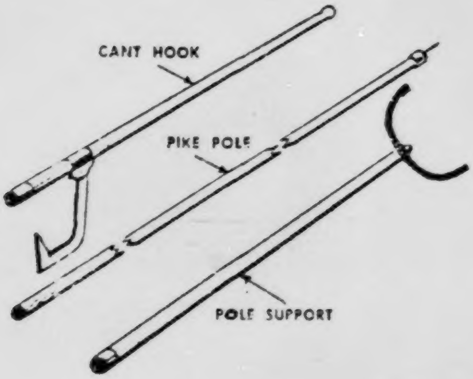

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Figure 9-5.—Pole tools.

This procedure is illustrated in figure 9-6 The "butt man" holds and guides the butt of the pole with "cant hooks" or a "peavey" (hook on a handle, the hook being designed to grasp the pole when pressure is applied to the handle). As the upper end of the pole is raised, a man keeps the jenny in approximate contact by moving it toward the butt. The "butt board" is a length of plank, set in the hole and long enough to protrude above the surface. It prevents the butt of the pole from sliding past the hole, and also prevents the butt from caving in the side of the hole. After the pole has reached upright position, it is "faced"—meaning that it is rotated with the cant hook to bring the crossarm gain to proper position. On a straight line it is the custom to set adjacent poles with crossarms facing in opposite directions, as shown in figure 9-7. This procedure called facing "gain to gain" or "back to back" provides for maximum strength in the line.

On a curve the gains must be set so that the crossarm is on the side of the pole nearest the center of the curve, as shown in figure 9-8.

After the pole has been faced, it must be plumbed vertical. This is done by four pikers on four sides of the pole, acting on signals given by one man who sights along the line and another who sights from one side. In some cases a small amount of rake or lean (approximately 12 inches) is left to allow for a wire strain or the normal give of a guy.

After the pole has been plumbed, the hole is backfilled and the backfill tamped down hard. Backfilling should be done gradually, in shallow layers, with each layer thoroughly tamped down. Usually two or three men tamp while a single man shovels. When the hole has been filled to the ground line with tamped backfill, the

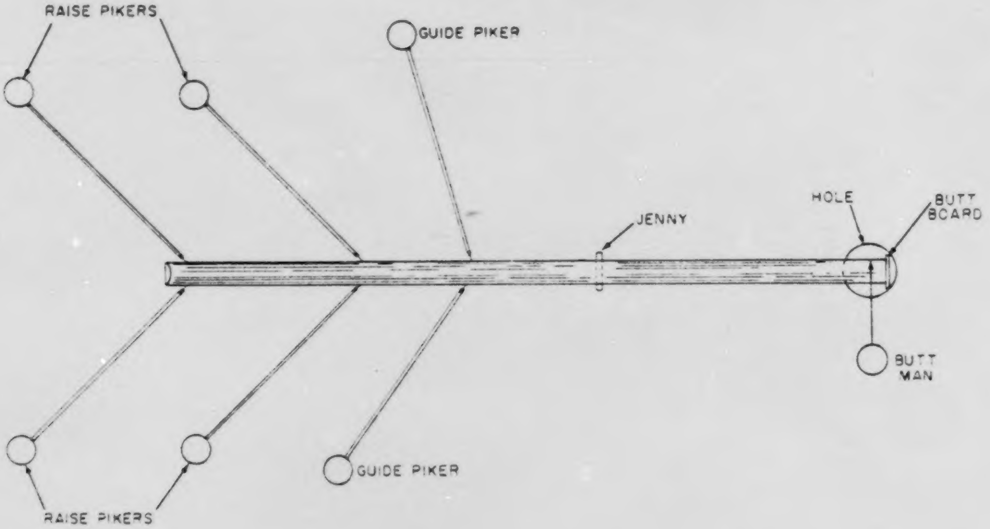

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Figure 9-6.—Piking up a pole.

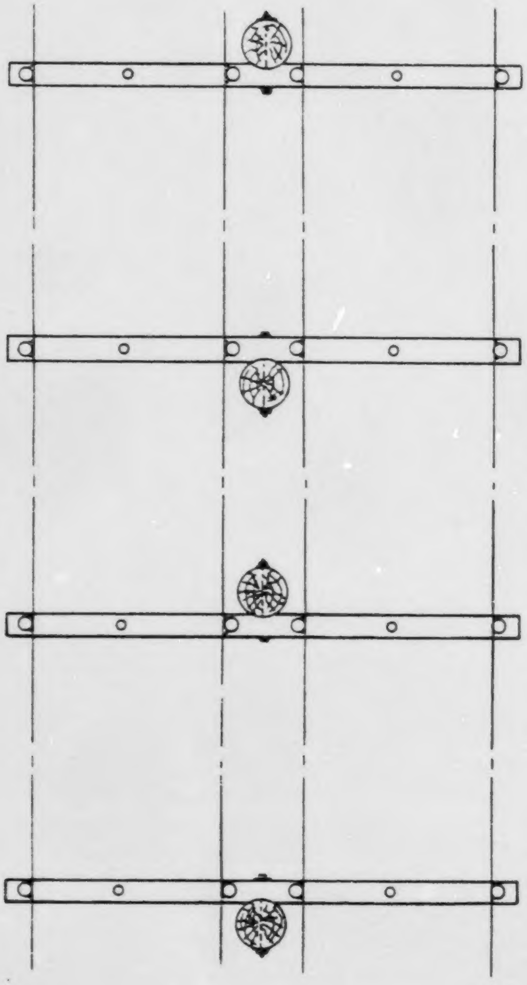

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Figure 9-7.—Facing crossarms on a straight line.

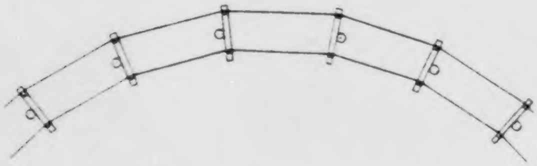

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Figure 9-8.—Facing crossarms on a curve.

remaining excavated soil is banked in a mound around the base of the pole, to allow for subsequent settling.

GUYING

A "guy" is a brace or cable which is "anchored" in some fashion at the lower end, and secured to a point on the pole at the other, and serves to brace the pole in position. Normally, cable or wire guy is made of 7-strand galvanized steel. There are various types of guys used, some of which are as follows:

A "line" guy is one installed in a straight pole line and parallel to the line, to reinforce the line against stress caused by broken conductors.

A "head" guy is one which runs from the top of one pole to a point below the top on another pole.

An "arm" guy is one which runs from the end of a crossarm to the next adjacent pole. It is used when a line dead-ends at the end of a crossarm.

A "storm" guy (fig. 9-9) is one installed in a line to prevent the entire line from being pulled down in the event that line conductors should break at some point in the line. A storm guy consists of two line guys (that is, guys running parallel to the line) and two side guys (guys running crosswise to the line). Storm guys are usually installed at intervals of 1/2 mi to 1 mi.

A "sidewalk" guy is outrigged (as shown in fig. 9-9), so the guy will not obstruct pedestrian traffic on the sidewalk.

A guy which runs from the top of a pole to a ground anchor is called a "down" guy.

A "stub" guy runs from the top of a pole to the top of a shorter pole called a stub. The stub is itself braced by a down guy.

Figure 9-9 shows some guys used in special situations.

Locating Guys

Guys are installed at any place in the line where the stress of the conductors could pull the crossarms or the pole out of proper position. It is not possible to mention all the situations which call for guying, but some important guy locations are as follows:

DEAD ENDS.—Dead ends or terminals must be guyed as shown in figure 9-9.

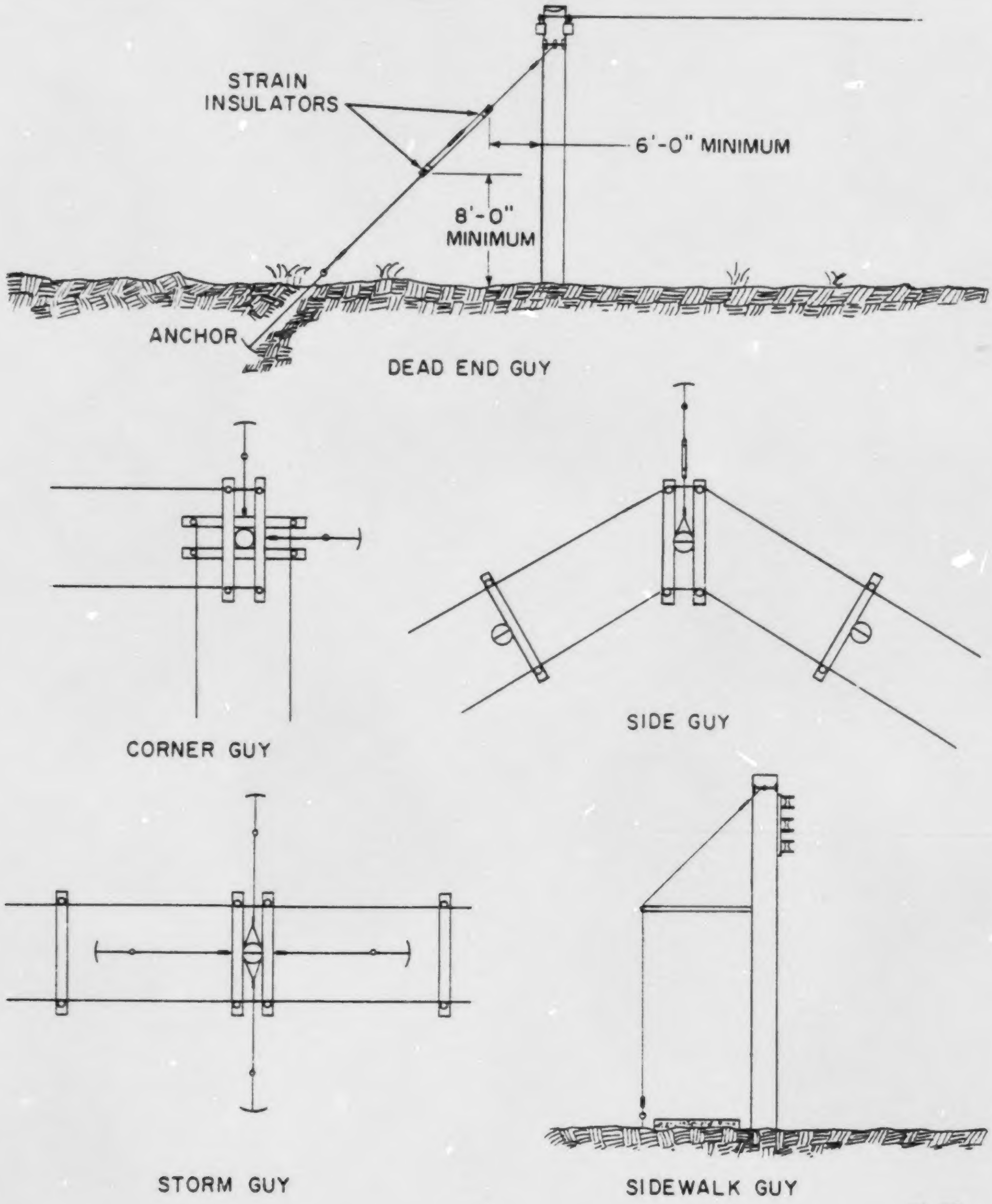

STRAIN INSULATORS
6'-0" MINIMUM
8'-0" MINIMUM
ANCHOR
DEAD END GUY
CORNER GUY
SIDE GUY
STORM GUY
SIDEWALK GUY
73.73

Figure 9-9.—Types of guys.

CORNERS.—Corners, that is, poles where the line changes direction radically—must be guyed as shown in figure 9-9.

BRANCHES.—Where a branch line takes off from a main line, a side guy should be installed to support the stress of the branch line.

ANGLES.—A corner is, of course, an angle, but it is an angle which comes close to 90°. When a line makes ANY angle, however slight, a side guy should be installed. For a large angle, two or more guys should be installed.

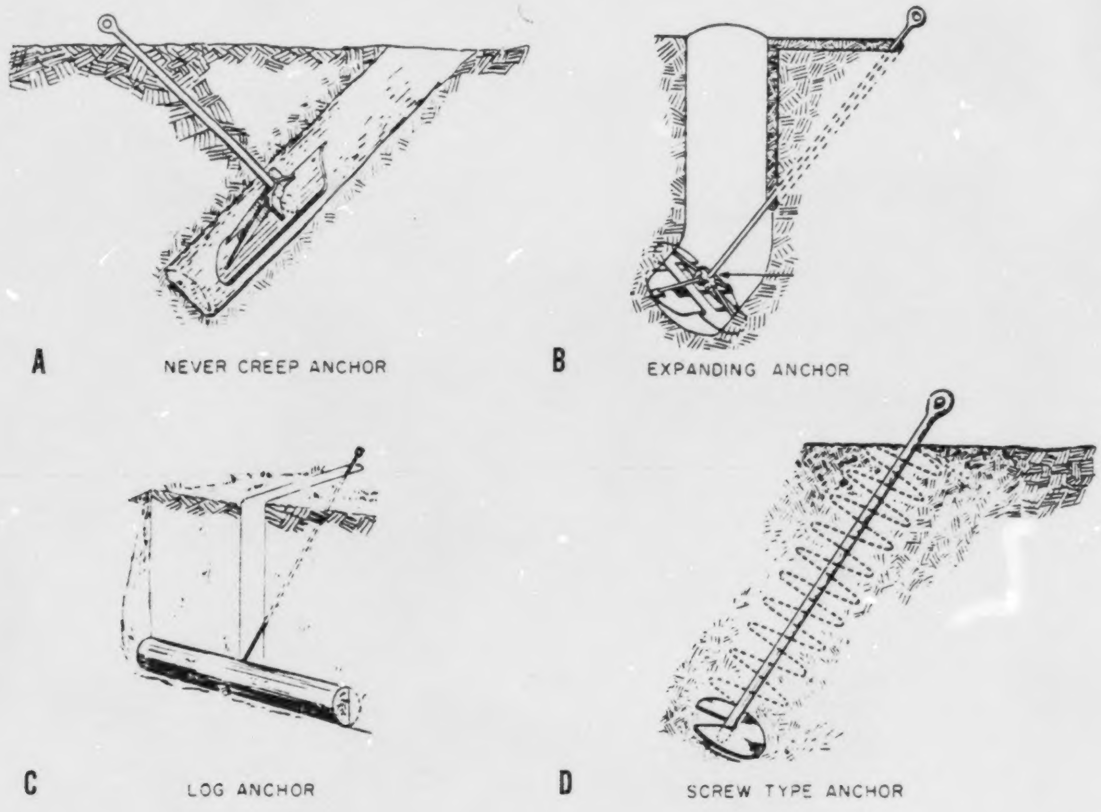
CROSSINGS.—Electric lines crossing railway tracks must be equipped with head guys installed on poles on both sides of the crossing. These guys run from the top of the pole adjacent to the tracks to about midway of the next pole.

Strain Insulators

All guys on power lines should have one, preferably two, strain insulators installed in the guy to break contact between the upper part of the guy and the part low enough to be contacted by persons on the ground. The lower insulator should be at least 8 ft above the ground and the upper one should be placed at least 6 ft from the pole to prevent electrical contact (fig. 9-9 top).

Guy Anchors

For securing the lower or ground ends of guys there are various types of "anchors" used, some of which are illustrated in figure 9-10. The "Never Creep" anchor (this is a trade name) is installed by digging a hole about 8 in. in diameter, at about a 45° angle and sloping toward the pole. After the hole is dug, a rod is driven in the ground closer to the pole and in line with the guy wire from the top of the pole. This rod intersects the hole at a right angle about 6 ft from the surface. The plate part of the anchor is then placed over the rod and locked on by the slot plate. A never creep anchor is shown in fig. 9-10A.



A NEVER CREEP ANCHOR

B EXPANDING ANCHOR

C LOG ANCHOR

D SCREW TYPE ANCHOR

73.74

Figure 9-10.—Types of guy anchors in general use.

The "expanding anchor" (fig. 9-10B) is installed by digging an 8-in. hole in line with the guy wire from the pole or at about a 45° angle. The anchor is put in the hole, and a heavy tamper is slipped over the rod. The anchor is rammed with the tamper until it expands to its full width. This usually takes about five or six blows with the tamper.

The "log" anchor (fig. 9-10C) is a simple do-it-yourself type which is very effective in soft or sandy soil. The log usually consists of a 6-ft long section of a pole which has outlived its usefulness. The trench is dug at right angles to the line of the guy, to a depth of at least 6 ft, and long enough to receive the log. A narrow trench, to accommodate the guy, is dug as shown. A threaded rod is run through a hole in the log and secured with nut and washer. The rod is long enough to permit the eye in the upper end to reach a point 6 in. above the ground line.

A "screw" type anchor is one which can be "screwed" into the ground as shown in figure 9-10D. A shallow hole is dug to start the screw blade, and the rod is then rotated by two men using a bar-toggle run through the eye.

CLIMBING POLES

To climb a wooden pole you are equipped with the equipment shown in the lower part of figure 9-11. The "stirrup" fits under the arch of your foot, and the leg iron runs up the inner side of the calf of your leg. This puts the "gaff" in a position on the inner side of your foot where you can drive it into the pole as you climb. Two leather straps run through the loop straps and hold the climber tightly against your calf and ankle. The "leather" pad keeps the upper end of the climber from digging into your leg.

The term "leather" refers not only to treated animal hides but also to neoprene impregnated nylon products such as body belts, safety straps and leg straps. These non-leather items are cleaned with soap and water and are available to the battalions.

The "safety strap" and "body belt" shown in the upper part of figure 9-11 are what might be called your extra pair of hands when you work aloft. The body belt, strapped around your waist, contains various pockets for small tools. The safety strap is a "leather" belt with a tongue-type buckle (keeper snap) at each end. While you are climbing you will have the safety strap hanging by both ends from the left ring (called a D-ring because of its shape) on the body belt. When you are at working position, you will unsnap one end of the safety strap, pass it around the pole, and hook it to the right "D" ring on the body belt. One adjustable buckle permits variation to suit the lineman and the circumference of the pole. You can now lean back against the safety strap and maintain a steady, comfortable, and SAFE position.

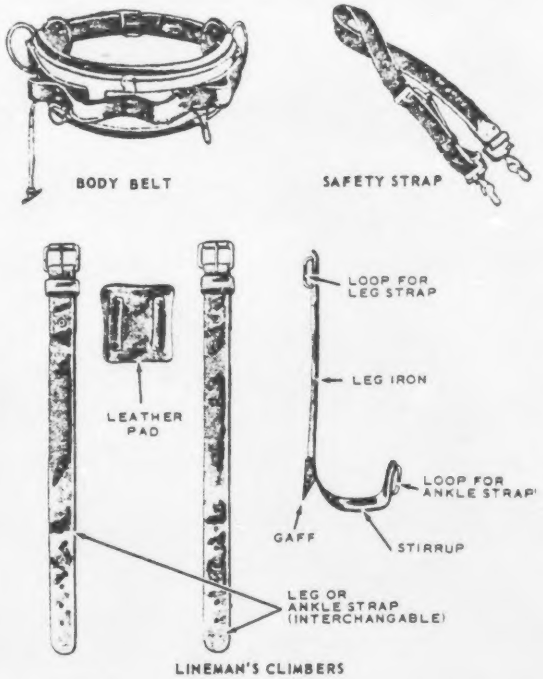


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Figure 9-11.—Pole-climbing equipment.

Care of Climbing Equipment

To a lineman the term "burning" a pole means the highly unpleasant experience of sliding all the way, or a good part of the way, down a pole as a result of defective equipment or some error in climbing technique made on the way up. The "burning" you get doesn't need to be explained in detail, and besides burning you may get a good many splinters. However, climbers, body belt, and safety belt should keep you up where you belong—if you use them properly and take proper care of them.

The body belt and safety strap require continuous inspection. Look for:

901

1. Loose or broken rivets.
2. Cracks, cuts, nicks, or tears in "leather."
3. Broken or otherwise defective buckles.
4. Defects in safety-belt snap hooks and body-belt D-rings.
5. Worn "leather."
6. Enlarged tongue holes for belt buckles.

If you discover any of these defects, turn in the equipment and replace it.

You must periodically perform maintenance work on the "leather" parts of your climbing equipment. Cleaning comes first. Use a damp sponge and a mild soap. Work up a thick, creamy lather. Then wash the soap off and wipe the belt with a dry cloth.

Next, to make the genuine leather soft and pliable, lather well with "saddle" soap. Work the lather into all parts; then place the belt in the shade to dry. After the lather has nearly dried, rub down the leather with a soft cloth.

Body belts and safety straps made of genuine leather require oiling about every 6 months. Be sure the leather is clean before applying oil. Use about 2 teaspoonfuls of neat's-foot oil, working the oil in gradually. Place the belt in a shady place and allow to dry for 24 hours. Then rub down with a soft cloth.

Always, before you climb a pole, inspect the climbers for the following defects:

1. Broken or loose straps.
2. Stirrup worn to a thickness of 1/8 in. or less.
3. Length of gaff of less than 1 1/4 in. as measured along inner surface.
4. Difference in gaff lengths of more than 1/8 in.

If you find any of these defects, turn in your climbers for a new pair.

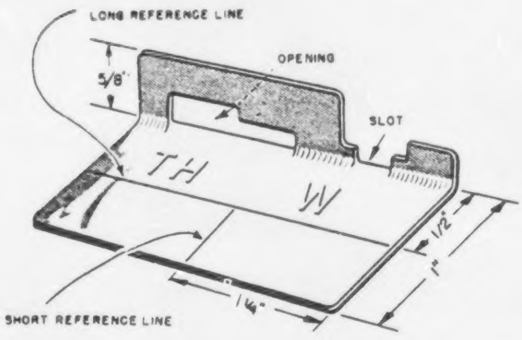

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Figure 9-12.—Climbers gage.

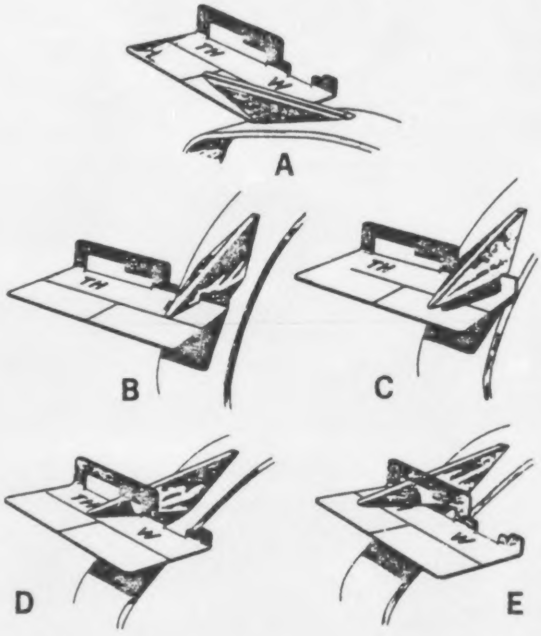

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Figure 9-13.—Use of climbers gage.

Climber's Gage

To minimize certain dangers which can occur from neglect of the climbers, be sure that you are aware of the advantageous use of climber gages (fig. 9-12). This gage is used to check the dimensions of gaffs. These must be within certain tolerances or the climber will "cut out" or lose contact with a pole or tree.

Measurements of the length, width, and thickness of the gaffs are made as follows.

LENGTH. Place the lined face of the gage against the inner surface of the gaff with the short edge of the gage held tightly against the crotch (fig. 9-13A). The crotch is the point where the gaff joins the leg iron. If the point of the gaff extends to or beyond the short reference line, the length of the gaff is satisfactory.

WIDTH. Insert the gaff as far as possible through the small slot marked W with the inner surface of the gaff resting against the lined face of the gage (fig. 9-13B). If the point of the gaff does not extend beyond the long reference line, the width of this section of the gaff is satisfactory. Insert the gaff as far as possible through the large slot marked W, with the inner surface of the gaff toward the lined face of the gage (fig. 9-13C). If the point of the gaff does not extend beyond the far edge of the gage, the width of this section of the gaff is satisfactory.

THICKNESS. Insert the gaff as far as possible through the small opening marked TH, with the inner surface of the gaff resting against the lined face of the gage (fig. 9-13D). If the point of the gaff does not extend beyond the reference line, the thickness of this section of the gaff is satisfactory. Insert the gaff as far as possible through the large opening marked TH, with the inner surface of the gaff resting against the lined face of the gage (fig. 9-13E). If the point of the gaff does not extend beyond the far edge of the gage, the thickness of this section of the gaff is satisfactory.

Sharpen any dull gaffs by taking long strokes with a file from the heel to the point of the gaff, removing only enough material to make a good point. NEVER USE A GRINDSTONE OR EMERY WHEEL TO SHARPEN GAFFS, since the metal may become overheated and lose its strength (temper). Never sharpen the gaff to a needle point (fig. 9-14) since it will sink too deep into the pole and make climbing difficult. Always leave a shoulder about 1/8 in. back from the point.

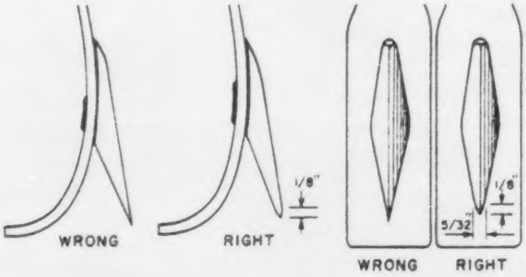

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Figure 9-14.—Sharpening the gaffs.

Remember that climbers are for use on poles ONLY. Do not wear them while working on the ground, and do not use the gaffs for such irregular procedures as the opening of cans and the like.

Going Up

To learn pole climbing you must practice actual pole climbing. However, there are a few tricks you can learn in advance. First, of course, make the preclimb inspection of equipment previously described AND PUT ON YOUR HARD HAT. Then inspect the pole to determine the best side on which to start. This is usually the back, or high side.

Get against the pole and grasp each side of it with your hands—not that you will hand-support your weight in climbing, but simply because you will use your hands to help in balancing yourself on the climbers (fig. 9-15).

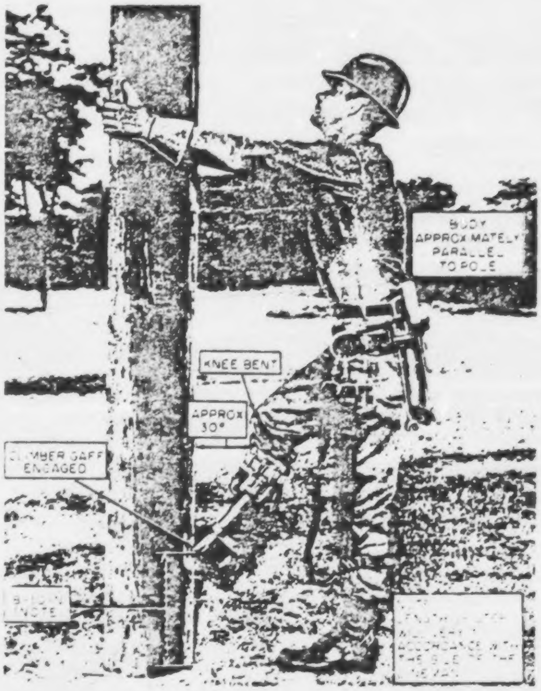

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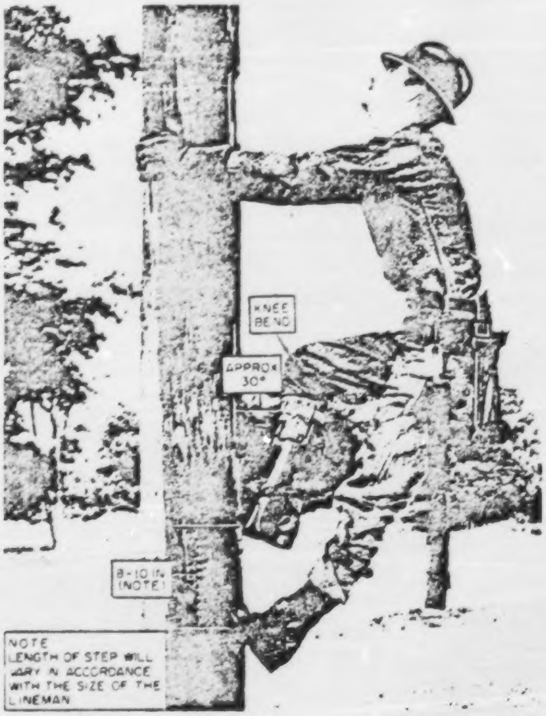
Figure 9-15.—Starting to climb a pole.

Raise your right leg about 8 in. off the ground and sink the gaff on that leg into the pole. Don't jab the gaff in the wood. Allow your weight to sink it in. Now, swing yourself up off the ground and lock your right leg in stiff-leg position, so that all your weight is supported on that leg.

Take the next step by raising your left foot about 8 in. and sinking the gaff on that foot into the wood. Then swing up onto the left leg stiff-legged, and take the next step similarly with the right foot. Continue this stepping up and locking stiff-legged until you reach working position. Keep the upper part of your body away from the pole; if you "hug" the pole, you will tend to throw the gaffs out of the wood (fig. 9-16).


KNEE BEND
APPROX 30°
8-10 IN (NOTE)
NOTE LENGTH OF STEP WILL VARY IN ACCORDANCE WITH THE SIZE OF THE LINEMAN

73.312
Figure 9-16.—Continuing the climb.

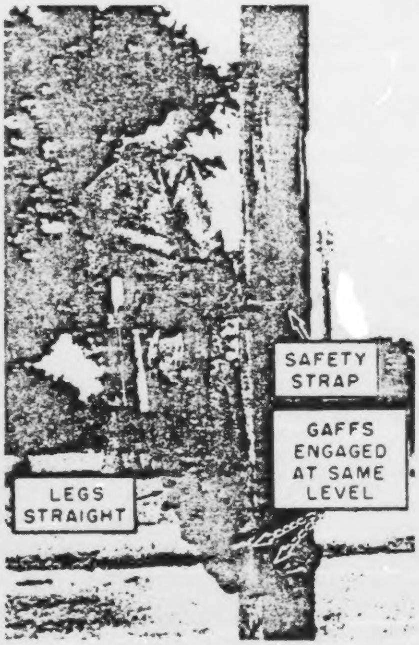
At Working Position

At working position your feet should be placed so that most of your weight is on the right foot, stiff-legged. The left foot should be slightly above the right, so that the left leg is slightly bent. When you have attained this position, you must proceed immediately, with great care, to attach the safety strap.

Crook your right arm around the pole. Use your left hand to unsnap one end of the safety strap from the left "D" ring on the body belt. Holding the end of the safety strap in your left hand, pass it around the back of the pole. Transfer the end of the safety strap from the left hand to the right hand, at the same time crooking your left arm around the pole to hold yourself in position. Then swing the end of the safety strap quickly around with your right hand and snap it onto the right D-ring on the body belt.

WARNING: Visually check to ensure that the snap engages the D-ring. Don't depend on the sound of the keeper snapping to indicate that the snaphook has engaged the D-ring.

You can now release your left arm gradually, so as to lean back against the safety strap (fig. 9-17).



73.313
Figure 9-17.—Working position.

Coming Down

Before you start down the pole you must release the safety belt. Crook your left arm around the pole, and unhook the safety strap from the right D-ring with the right hand. Pass the end of the safety strap to the left hand, crook your right arm around the pole, and snap the end of the safety strap to the left D-ring.

You are now ready to descend. Break out the left gaff by swinging the left knee out from the side of the pole. Step down with the left foot to a point about 12 in. below the right; stiff-leg the left leg, and bring your weight on it to sink the gaff. Then break out the right gaff by swinging the right knee away from the pole (fig. 9-18) and proceed as formerly with the left leg. Continue this stepping-down process until you have reached the ground.

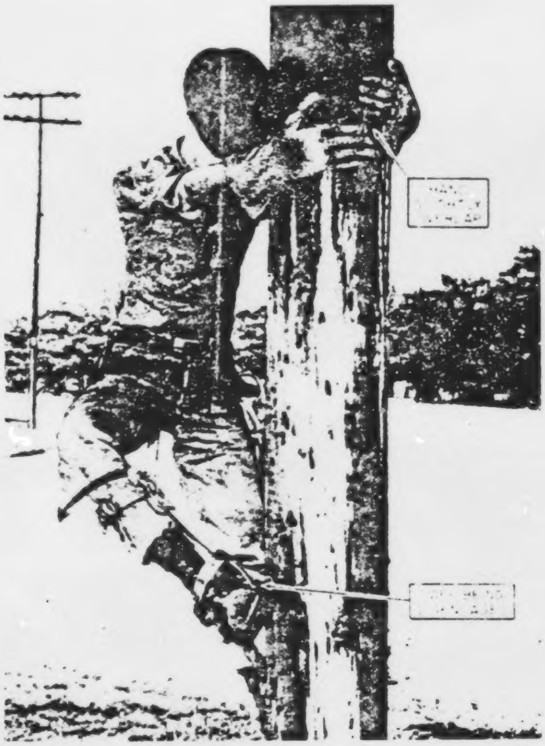


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Figure 9-18.—Descending.

Pole-Climbing Safety

As you work aloft, keep the following precautions constantly in mind:

1. NEVER carry tools or other objects in your hand when climbing.
2. NEVER trust pins, crossarm braces, or guy wires as supports.
3. If you are working with another man on the same pole, and he goes up first, wait until he is strapped in working position before you start up.
4. Do not depend on the snapping sound when you snap the safety strap to a D-ring. Look down to ensure that the snap is engaged to the ring.
5. If the top crossarm is near the top of the pole, do not pass the strap around the short length of pole protruding above the crossarm.

MOUNTING CROSSARMS AND RACKS

Crossarms are made in a variety of sizes, the size used depending on the voltage on the line and the number of conductors. For average use, a "six-pin" arm with four pins occupied by conductors, is common. The size of this arm gives a good clearance space between conductors.

Crossarms are sometimes mounted on a pole before the pole is raised and set in the ground. This gives the man doing the sighting an advantage. When a crossarm is mounted before the pole is set up, the crossarm through bolt is set up tight, but the crossarm braces are left hanging loose. After the pole is set, the crossarm is leveled and the braces then attached. Finally, the through-bolt is set up hard.

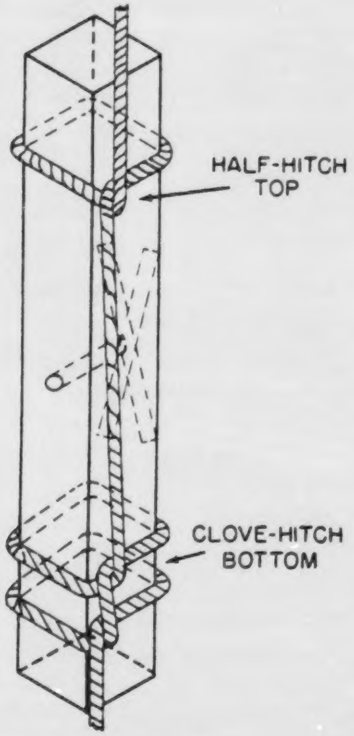
If the crossarm is mounted after the pole is set, it is pulled up to a lineman in working position by a helper on the ground, using a handline attached as shown in figure 9-19. With the handline attached in this fashion the lineman can, after he inserts the through bolt, cast off the upper half-hitch, and the helper on the ground can then heave the crossarm level.

Braces are usually fastened to a crossarm with 3/8-in. by 4-in. carriage bolts. Each brace comes down diagonally and is attached to the pole at the lower end with a 1/2 in. lag screw.

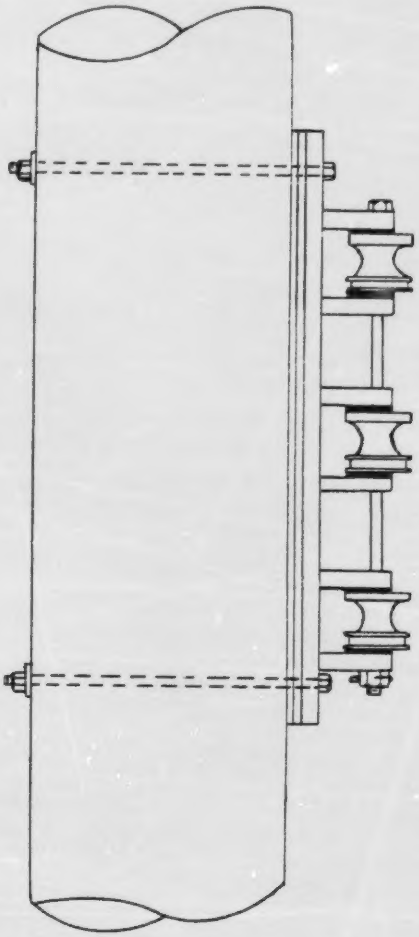
On a straight line without excessive strains, crossarms are used singly-mounted face-to-face or back-to-back, as previously mentioned. At line terminals, corners, angles, or other points of excessive strain, crossarms are doubled. Where a power line crosses a railroad or a telephone line, crossarms should be doubled.

When double arms are used, they are fastened together at the ends with double-arm bolts. One of these is threaded all the way, and has two square washers and two nuts on each bolt between the arms. The lineman can adjust the spacing between a pair of crossarms by setting these nuts the desired distance apart on the threaded bolts.

905



73.75
Figure 9-19.—Cross arm, showing the proper way to fasten handline.



26.85(73)
Figure 9-20.—Secondary rack.

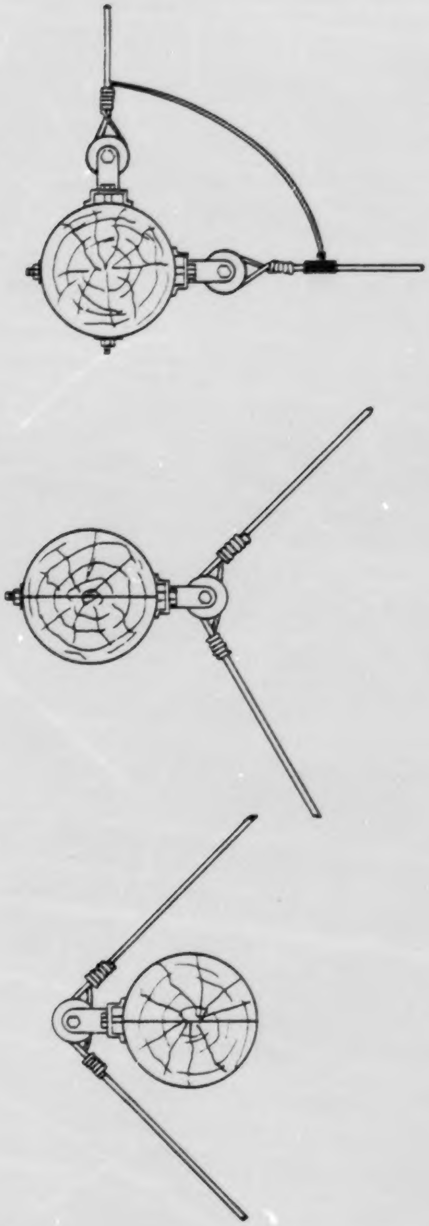
SECONDARY RACKS

Secondary conductors may be strung on crossarms, but are usually put on secondary "racks." These racks are made in sizes to accommodate 2, 3, or 4 conductors. A secondary rack is mounted on the side of a pole (for a straight run) or on the inside of a pole (for a dead end) as shown in figure 9-20. A rack is fastened to the pole with lag bolts on a straight line, with a through bolt at the top and lag screw at the bottom, or with through bolts with nuts for a dead end or where a branch line takes off from the main line.

Insulators are held to a rack by a rod passing through the insulators and brackets on the rack as shown in figure 9-18. On a straight line or inside angle the conductor is run on the inside of the insulator. On an outside angle it is run on the outside. The conductor is always placed with strain against the insulator. Figure 9-21 shows rack arrangements at corners and angles.

Another type of secondary construction consists of a patented bracket for holding a single conductor. This bracket can be opened in such a way as to permit the conductor to be pulled over the insulator, which revolves like a pulley during the process. After the conductor has been pulled up to proper sag, the conductor is tied in and the bracket snapped up into vertical position.

1254



73.77

Figure 9-21.—Rack arrangements at corners and angles.

STRINGING THE CONDUCTORS

There are various ways of stringing the conductors. One method includes placing the reels on a truck or trailer and driving along the line of right of way, unreeling the wire. This method has the advantage of not allowing the wire to drag on the ground, but in some locations you may not be able to drive a truck along the right of way because of rough terrain.

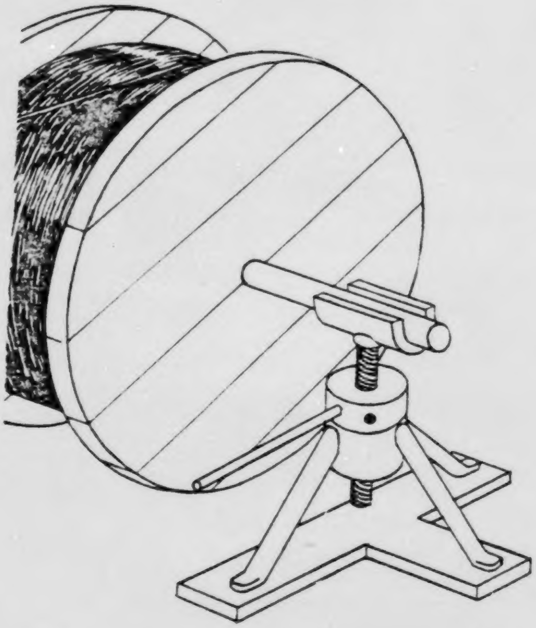
No matter how you string the wire, you will have to mount the reels on some support that allows them to revolve freely. This is usually done by raising a reel on cable jacks as shown in figure 9-22. A metal rod strong enough to support the reel is put through the hole in the center, and the rod and reel are jacked up on each side, with the leg of the "T" base away from the reel as shown. You may have to fasten down the bases of the jacks to keep the strain from upsetting the reel. When jacking up, it is only necessary to raise the reel just clear of the deck.

When stringing wire in rough terrain, the best method is to anchor a reel to the ground at the end of the line by means of guys run to driven stakes. A rope line is then run over the crossarms for a horizontal distance of from 1000 to 1500 ft. This line is draped on each crossarm by a lineman climbing the pole.

After the rope has been strung over the crossarms, one end is secured to the wires to be pulled, and a couple of turns taken with the other end around the winch drum on the line truck. The drum is then rotated to haul in the rope, and the wires with it. As each wire passes a crossarm, a lineman must climb the pole to set the wire in proper position and guard against twisting.

To keep a paying-out reel from revolving too fast, a brake or drag is set against the reel. This can be simply a board, held against the outer edge of the reel by a helper. As a wire or wires are being pulled, enough men must be stationed along the way to establish a chain of signal communication from the head of the line back to the line truck.

A neutral wire should always be placed on a center crossarm pin or on a pole-top pin. With a secondary rack, put the neutral wire on the top spool, so the neutral can protect the hot wires against anything that might fall from above. Putting the neutral on a center or pole pin also gives the lineman a clear space around



73.78

Figure 9-22.—Cable reel on reel jack.

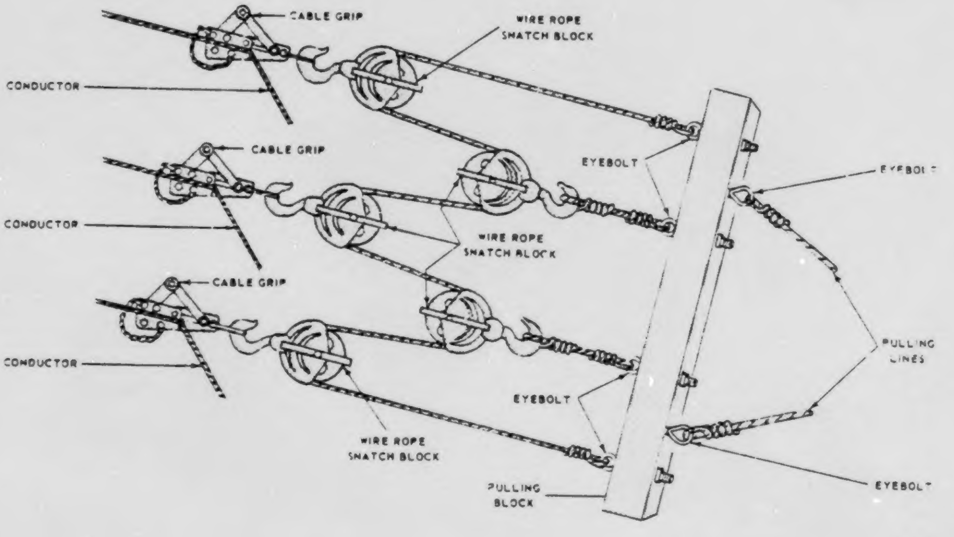
the pole to climb through—that is, it ensures that the hot wires are a considerable distance apart.

When the conductors have been hoisted in place on the crossarms and dead ended on one end, you are ready to start "pulling in"—that is, heaving on the conductors until each has been raised to proper sag. This is done with a tackle equipped with a cable grip (commonly called a "come-along") like those shown in figure 9-23. A cable grip is a clamp-type device which grips the wire tightly when a strain is applied to the grip.

When pulling two or more wires at once, it is best to use the equalizer shown in figure 9-23. This device distributes the strain equally on all the wires.

When wires have been pulled to approximately the desired sag, a lineman goes to the center span to measure the sag. Measurement at the center of each span ensures uniform measurement. Three common ways of measuring sag are by dynamometer, by timing vibration, and by the use of targets.

A lever-cam dynamometer is an instrument which is installed in the pulling line and which measures the strain of the pull. It is used in conjunction with a chart which gives the desired


CABLE GRIP
WIRE ROPE SNATCH BLOCK
CONDUCTOR
EYEBOLT
EYEBOLT
CABLE GRIP
CONDUCTOR
WIRE ROPE SNATCH BLOCK
CABLE GRIP
PULLING LINES
CONDUCTOR
EYEBOLT
WIRE ROPE SNATCH BLOCK
PULLING BLOCK
EYEBOLT

73.79

Figure 9-23.—Pulling wires with equalizer.

pull tension for a given conductor size, span length, and temperature. A traction dynamometer, also installed in the pulling line, provides direct readings on the face of the dial.

The timing-vibration process is done by striking the wire sharply near one of the pole supports, and timing by stop watch the interval which elapses during which the impulse from the blow travels to the next pole and returns. This system is not accurate if a wind is swinging the line, or if the line is being worked on in an adjacent span.

The target-sighting method is a simple and accurate means for measuring sag. The desired sag is first ascertained from table 9-2.

Figure 9-24 illustrates the effect of temperature on the sag in a 200-ft span of 00 wire. You target-measure sag by nailing slat targets, such as a couple of pieces of wood lath, on each pole a distance below the conductor insulator equal to the desired amount of sag. A lineman then sights from one slat to the other, and the conductor is hauled up or lowered until its lowest point is on the line of sight between the slats (fig. 9-25).

After the wires are "sagged in," you allow a rest period of from a 1/2-hour to 4 hours (varying according to the length of the pull), to let the wires adjust themselves to the tension in the pull. They will gradually "creep" until tension in all the spans is equalized. After they have crept to the final position, you are ready to "tie in."

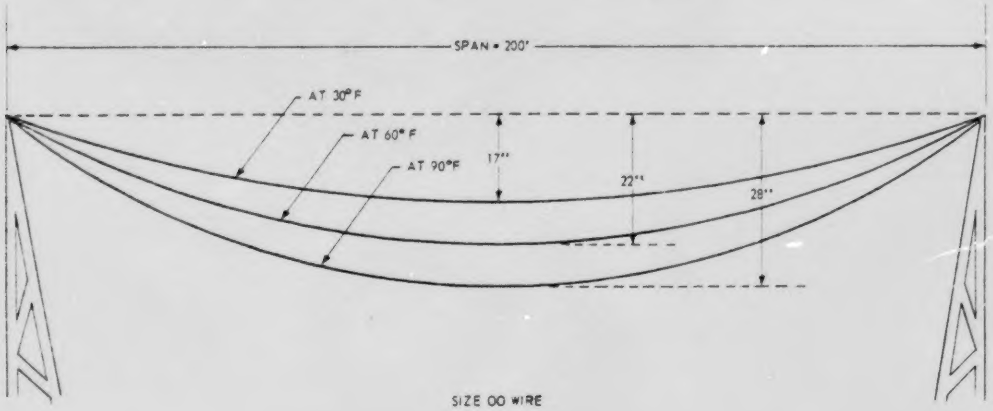
TYING IN CONDUCTORS

Tie wire fastens the conductor and insulator together. Conductors can be tied in various

Table 9-2.—Sag variation with temperature.

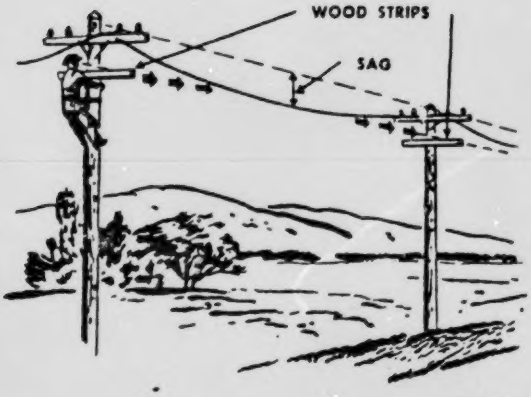
No. (awg)	Temperature (degrees F)	Sag in inches for span lengths of					
		100 ft	125 ft	150 ft	175 ft	200 ft	250 ft
6	30	5.5	8.5	13	18.5		
	60	8	12	18	24		
	90	12	17	23.5	30		
4	30	5.5	8.5	13	18.5	25	35
	60	8	12	18	24	32	42
	90	12	17	23.5	30	39	50
2	30	5.5	8.5	13	16.5	20	29
	60	8	12	18	22	26	36
	90	12	17	23.5	28	33	44
1	30	5.5	8.5	13	15.5	28.5	24.5
	60	8	12	18	21	24	31
	90	12	17	23.5	28	31	39
0	30	5.5	8.5	13	15.5	18	23.5
	60	8	12	18	20.5	23	29
	90	12	17	23.5	27.5	29.5	36
00	30	5.5	8.5	13	15	17	21
	60	8	12	18	20	22	27
	90	12	17	23.5	26	28	34
0000	30	5.5	8.5	13	14.5	16	19
	60	8	12	18	19	21	24
	90	12	17	23.5	25	27	30

73.244



73.80

Figure 9-24.—Effect of temperature on sag in 200-ft span of 00 wire.



73.315

Figure 9-25.—Adjusting sag.

ways, but the ties shown in figure 9-26 are the ones most commonly used. Hold the tie wire tight against the insulator as you make your wraps around the insulator and the conductor wire.

In tying in wires observe the following procedures:

Always use new fully annealed wire for ties. Hard drawn wire is brittle and cannot be pulled up against conductor and insulator.

Use the proper size wire. For No. 8 bare use No. 8 bare. For No. 6 or No. 4 bare, use No. 6 bare. Use No. 4 bare for No. 2 conductor. Use No. 2 bare wire for No. 1/0 through 4/0 bare conductor.

Use a piece of tie wire that is long enough to make the complete tie, with enough left over this to allow grasping. After the tie is completed, cut off the excess and form a loop or eye at the end of any projecting end of the wire.

Make positive contact between tie wire and conductor to avoid chafing and to limit possibilities of causing interference with radio communications.

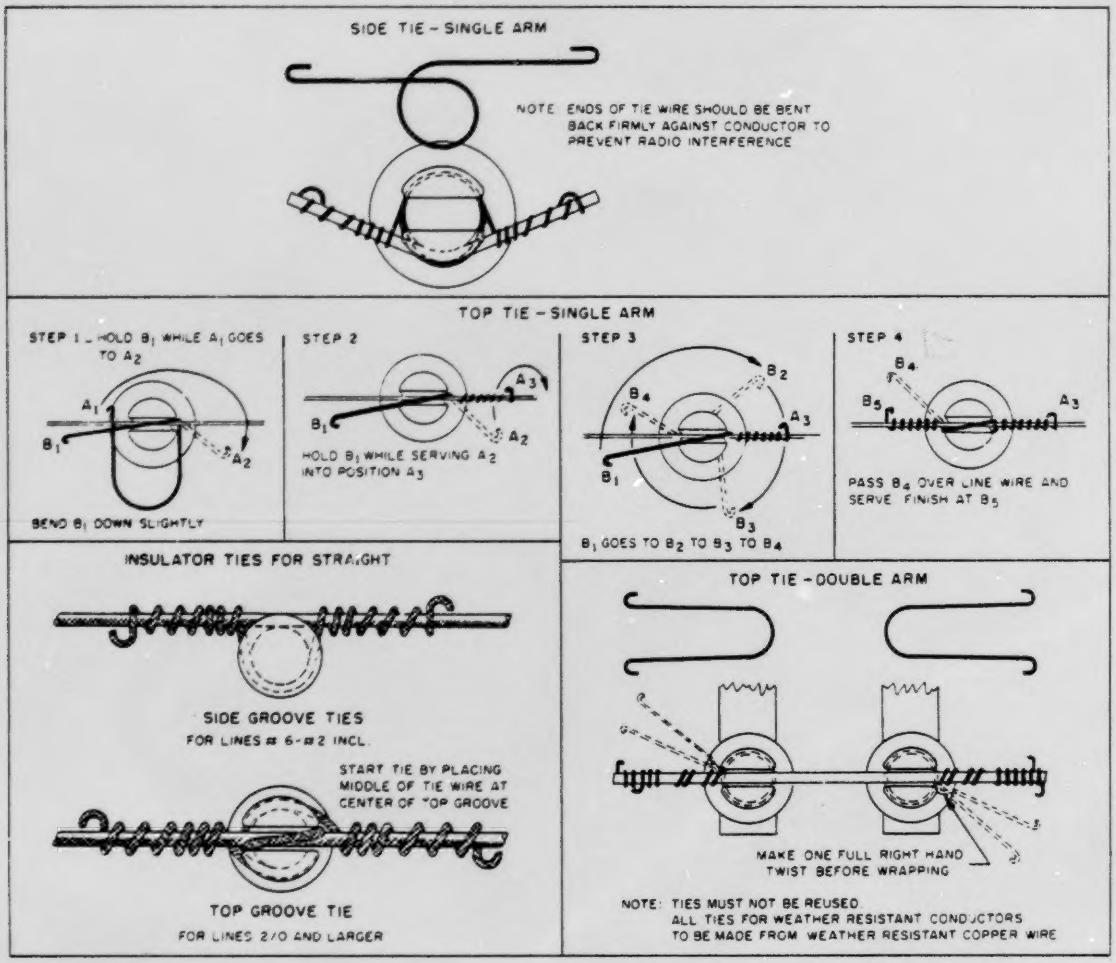
INTERFERENCE ELIMINATION

Powerlines may be a source of interference with radio communication. Conductors, insulators, and hardware contribute their share by means of spark discharges, localized corona discharge and cross modulation.

Spark discharges occur when localized excessive voltage stress exists. A conductor may become partially insulated by corrosion products or an insulator partially conductive due to cracks. A third source of stress occurs when a conductor is placed with but a small air gap between it and another metallic part of a pole.

Corona is defined as the luminous discharge due to ionization of the air in the vicinity of a conductor when the voltage gradient exceeds a certain critical value.

Cross modulation (often the result of a corroded connection which causes non-linear rectification of currents) may occur when splices are made by twisting or serving the conductors rather than the more positive mechanical splice. Additionally, when conductors of dissimilar


SIDE TIE - SINGLE ARM
NOTE ENDS OF TIE WIRE SHOULD BE BENT BACK FIRMLY AGAINST CONDUCTOR TO PREVENT RADIO INTERFERENCE
TOP TIE - SINGLE ARM
STEP 1 _ HOLD B_1 WHILE A_1 GOES TO A_2
A_1
B_1
A_2
BEND B_1 DOWN SLIGHTLY
STEP 2
A_3
B_1
A_2
HOLD B_1 WHILE SERVING A_2 INTO POSITION A_3
STEP 3
B_2
B_4
A_3
B_1
B_3
B_1 GOES TO B_2 TO B_3 TO B_4
STEP 4
B_4
B_5
A_3
PASS B_4 OVER LINE WIRE AND SERVE FINISH AT B_5
INSULATOR TIES FOR STRAIGHT
SIDE GROOVE TIES
FOR LINES # 6-#2 INCL.
START TIE BY PLACING MIDDLE OF TIE WIRE AT CENTER OF TOP GROOVE
TOP GROOVE TIE
FOR LINES 2/0 AND LARGER
TOP TIE - DOUBLE ARM
MAKE ONE FULL RIGHT HAND TWIST BEFORE WRAPPING
NOTE: TIES MUST NOT BE REUSED.
ALL TIES FOR WEATHER RESISTANT CONDUCTORS TO BE MADE FROM WEATHER RESISTANT COPPER WIRE

73.316

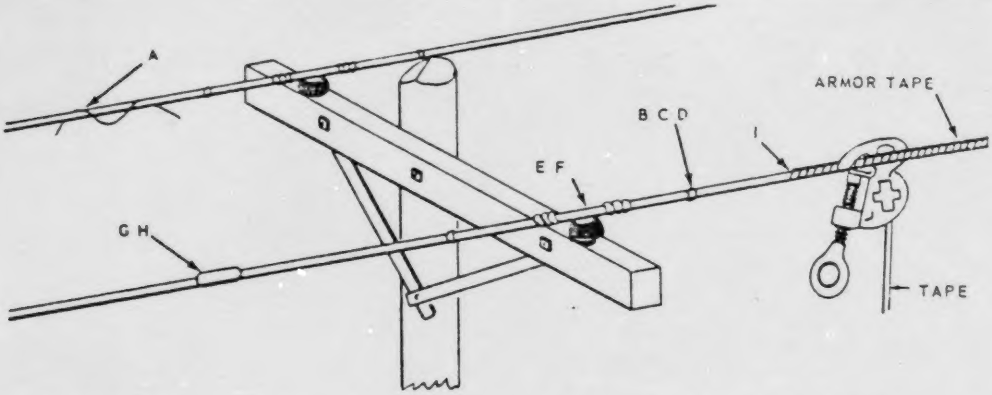
Figure 9-26.—Tying in conductors.

metals are joined, corrosion will occur unless special connectors designed for the specific combination of metals are used.

Remedies for conductor, insulator, and hardware interference are relatively simple (figs. 9-27-9-29). Remember, the conditions for hardware interference are set up whenever two pieces of hardware are not securely bonded to each other or are permanently separated by too short an air gap.

Additional specific precautions to take to minimize conductor and hardware interference include the following.

- Maintain at least a 2-inch clearance through or along wood, and a 1 1/2-inch clearance through air from metal insulator pins to any other metal parts such as crossarm braces, through-bolts, square washers, molding staples, conduit, brackets for arresters and cutouts, deadend attachments, ground wires, etc.
- Permanently bond crossarm braces together on circuits greater than 5 kilovolts. Use wood crossarm braces.
- Where local electrical safety codes permit, bond metal insulator pins together on circuits above 5 kilovolts.


A
ARMOR TAPE
B C D
I
E F
G H
TAPE

A. KEEP CONDUCTOR CLEAR OF BITS OF WIRE, KITE STRINGS, ETC.

B. KEEP ENDS OF TIE WIRES AWAY FROM INSULATOR.

C. USE ONLY BARE, SOFT TIE WIRE.

D. AVOID SHARP POINTS AND PROTRUDING ENDS ON TIE WIRE.

E. MAKE SURE TIE WIRE IS TIGHT.

F. STRIP INSULATION FROM CONDUCTOR AND MAKE CLOSE CONTACT WITH THE INSULATOR.

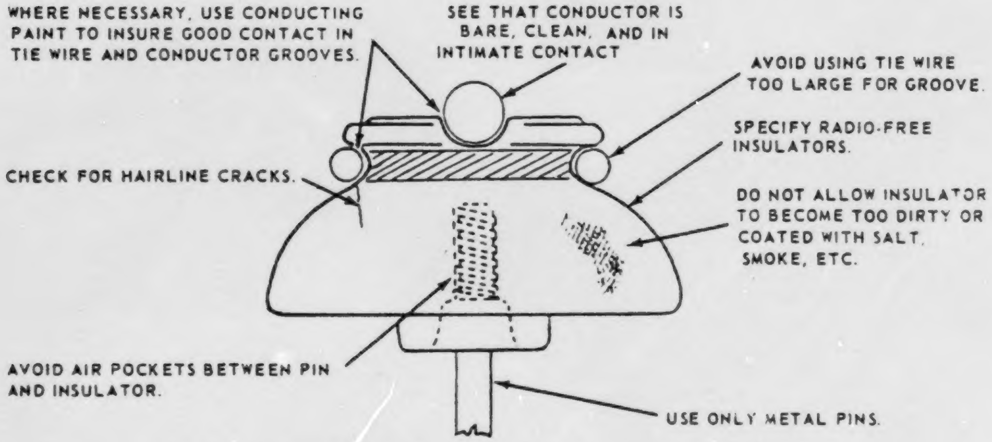
G. USE ONLY APPROVED PRESSURE CONNECTORS, AUTOMATIC SPLICE, OR SLEEVES FOR SPLICE.

H. USE SPECIAL BIMETAL CONNECTORS TO CONNECT DISSIMILAR METAL CONDUCTORS.

I. USE ARMOR TAPE AND GRADE A *NO-OXIDE* UNDER HOT LINE CLAMP ON CONDUCTOR.

73.317

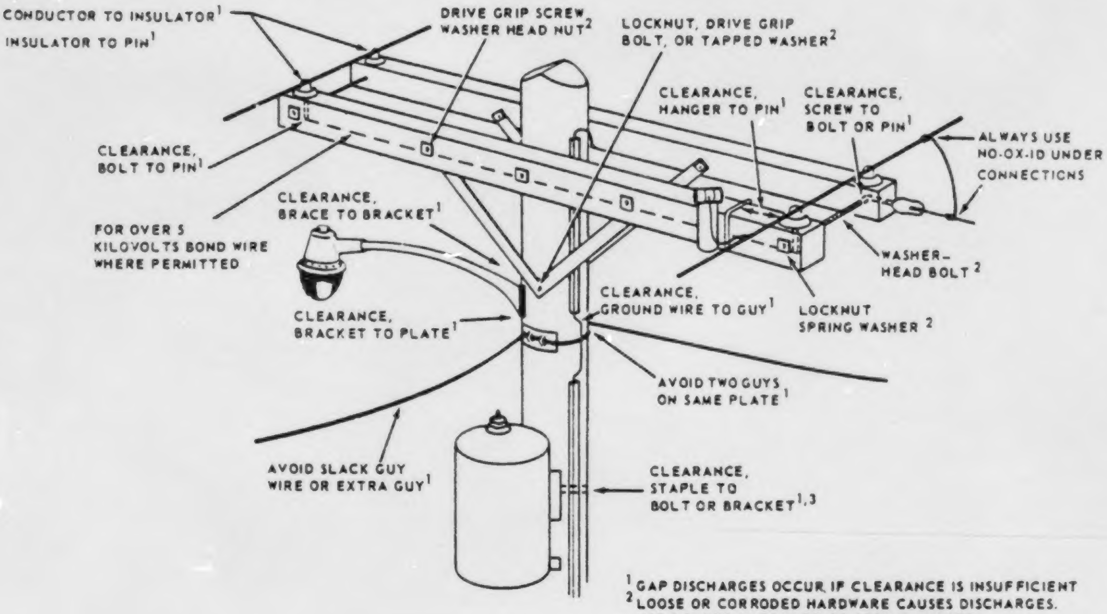
Figure 9-27.—Corrections for common sources of conductor interference.


WHERE NECESSARY, USE CONDUCTING PAINT TO INSURE GOOD CONTACT IN TIE WIRE AND CONDUCTOR GROOVES.
SEE THAT CONDUCTOR IS BARE, CLEAN, AND IN INTIMATE CONTACT
AVOID USING TIE WIRE TOO LARGE FOR GROOVE.
SPECIFY RADIO-FREE INSULATORS.
CHECK FOR HAIRLINE CRACKS.
DO NOT ALLOW INSULATOR TO BECOME TOO DIRTY OR COATED WITH SALT, SMOKE, ETC.
AVOID AIR POCKETS BETWEEN PIN AND INSULATOR.
USE ONLY METAL PINS.

NOTES:
1. USE FOG-TYPE INSULATORS IN AREAS WHERE FOG IS COMMON.
2. USE CLAMP-TOP POST TYPE INSULATORS AT VOLTAGES OF 24 KILOVOLTS AND HIGHER.

73.318

Figure 9-28.—Insulator interference corrections.


CONDUCTOR TO INSULATOR¹
INSULATOR TO PIN¹
DRIVE GRIP SCREW WASHER HEAD NUT²
LOCKNUT, DRIVE GRIP BOLT, OR TAPPED WASHER²
CLEARANCE, HANGER TO PIN¹
CLEARANCE, SCREW TO BOLT OR PIN¹
ALWAYS USE NO-OX-ID UNDER CONNECTIONS
CLEARANCE, BOLT TO PIN¹
CLEARANCE, BRACE TO BRACKET¹
FOR OVER 5 KILOVOLTS BOND WIRE WHERE PERMITTED
WASHER-HEAD BOLT²
CLEARANCE, GROUND WIRE TO GUY¹
LOCKNUT SPRING WASHER²
CLEARANCE, BRACKET TO PLATE¹
AVOID TWO GUYS ON SAME PLATE¹
AVOID SLACK GUY WIRE OR EXTRA GUY¹
CLEARANCE, STAPLE TO BOLT OR BRACKET¹,³

[1] GAP DISCHARGES OCCUR IF CLEARANCE IS INSUFFICIENT

[2] LOOSE OR CORRODED HARDWARE CAUSES DISCHARGES. USE BONDED HARDWARE OR SPRING WASHER.

[3] USE GROUND CLIPS FOR FASTENING GROUND WIRE TO POLE. USE GALVANIZED STEEL OR COPPERWELD STAPLES OVER WOOD MOLDING.

73.319

Figure 9-29.—Possible sources of hardware interference and means of prevention.

- Use double-coil spring washers on all bolts of attachments that support primary conductors, including primary neutral or common neutral supported on primary crossarms.
- Use ground wire clips in place of staples when attaching ground wires directly to a pole of crossarm. If metal clips are to be used on weatherproof or other types of covered ground wire, remove sufficient covering from the wire so that the metal clip will make good contact with the wire. If plastic clips are used, this procedure is not necessary.
- Insure that ground wires, bond wires and all staples/clamps are at least 1 1/2 inches from any ungrounded metal parts such as transformer brackets, crossarm braces, and through bolts.
- Clamp bond or ground wires only against other metal parts and with a washer or locknut.
- During construction, a lag screw with or without a double-coil washer under the head should be screwed, not driven, into place for the last 1 inch of its length.

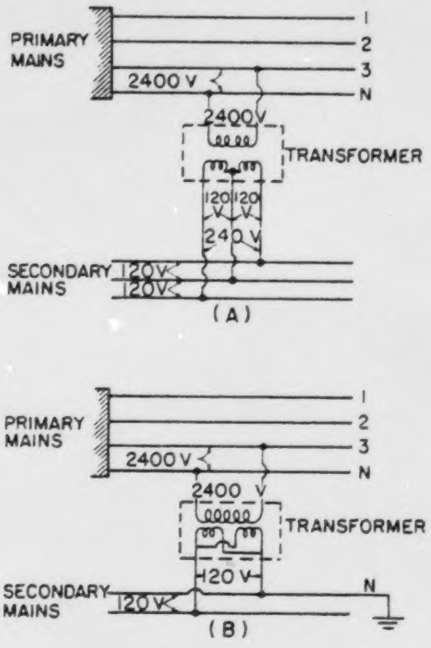
DISTRIBUTION TRANSFORMERS

For long-distance power transmission a voltage higher than that normally generated is required. A transformer is used to step the voltage up to that required for transmission. Then, at the service distribution end, the voltage must be reduced to that required for lights and equipment. Again a transformer is used, this time to step down the voltage.

Transformers are explained in Basic Electricity. To the discussion given there, the following may be added.

PRIMARY AND SECONDARY CONSTRUCTION

The change in voltage in a transformer depends on the number of turns of wire in the coils. The high-voltage winding is composed of many turns of relatively small wire, insulated to withstand the voltage impressed on it. The secondary winding is composed of a few turns



73.83

Figure 9-30.—Single-phase transformer with secondary windings connected in series and parallel.

of heavy copper wire large enough to carry high current at a low voltage. Figure 9-30 shows a single-phase transformer, with secondary windings connected series and parallel.

In a distribution transformer a secondary coil is wound on each leg of the laminated iron core, and the primary coil is wound over the secondary coils. The primary leads pass through a steel tank and are insulated from the tank by porcelain bushings. The secondary leads are connected to studs on a terminal block. Copper straps on the secondary terminal block permit connecting the two secondary coils in series or in parallel. From the terminal block, three secondary leads pass through porcelain bushings to the outside of the tank. An oil-level line inside the tank marks the level to which the tank is filled with transformer oil.

TRANSFORMER OIL

Transformer oil, which has high insulating quality, serves two purposes. First, it insulates the coils. Second, it helps dissipate the heat generated by resistance of the windings and eddy currents in the iron core. If this heat were not removed in a satisfactory manner, the transformer would operate at excessively high temperature, which would in turn damage or destroy the insulation on the coils.

OTHER COOLING METHODS

There are several other methods of cooling transformers, such as self air-cooling, air-blast cooling, liquid immersed self-cooling, and liquid immersed water cooling. Self air-cooled types are simply cooled by surrounding air at atmospheric pressure, the heat being removed by natural convection (normal dissipation of heat by cooling). This type is called the dry type transformer.

The air-blast cooled transformer has the core and windings enclosed in a metal enclosure through which air is circulated by a blower. This type is used for large power transformers with ratings up to from 12,000 to 15,000 kva.

The liquid-immersed self-cooled transformer is the type previously described—that is, with coils and core completely immersed in transformer oil. In the larger sizes, the tanks are provided with external tubes or external radiators through which the oil circulates by natural convection caused by the differences in temperature in the liquid.

The liquid-immersed water-cooled transformer is sometimes used where there is a plentiful supply of cooling water available. In this type a coil of copper or brass pipe is installed near the top of the tank in the cooling oil. Water is circulated through this coil and carries away the heat from the oil as it rises in the tank.

SINGLE-PHASE AND POLYPHASE TRANSFORMERS

Transformers are built in both single-phase and polyphase units, but on military installations the single-phase type is the one most often used. By connecting three single-phase transformers in a single bank, the same results are obtained as would be with one three-phase transformer; and the bank is more flexible. With the three-phase transformer, a failure in the transformer interrupts the service more than would a failure of a single transformer in a bank of three single-phase transformers. The three-phase transformer is also more bulky, and therefore harder to handle, especially for pole or platform mounting.

MOUNTING TRANSFORMERS

Transformers are equipped with various facilities for mounting. Some are made with lugs on the back of the metal enclosure for direct mounting on a pole by means of through-bolts. Others have lugs for mounting on cross-arm type brackets. Still another type, called the platform type, is suitable for mounting the transformer on its own base. One of these may be mounted on any flat surface of sufficient supporting strength—such as a concrete platform on the ground, or a wooden platform on sills.

TRANSFORMER LOAD

Most transformers are rated according to the kva load the transformer can carry without developing a temperature rise of more than 55°C (about 131°F), given the following conditions:

1. The transformer is operating at the rated voltage, or not in excess of 105 percent of the rated voltage.
2. The transformer is operating at the rated frequency.
3. The temperature of the surrounding air at no time exceeds 40°C (104°F), and the average during any 24-hour period does not exceed 30°C (86°F).

The 55°C allowable temperature rise is a common standard; however, the nameplate of a particular transformer may indicate a different standard.

The proper loading of a transformer also depends on the balancing of the load on the distribution conductors. This balancing should be checked periodically with a clamp-on ammeter, to ensure that the circuit is correctly balanced. You may at times have to shift some of the load from one phase to another to keep the load balanced in the transformer.

When current is being supplied to a motor by a transformer, the kva rating of the transformer should be at least as high as the hp rating of the motor—meaning that a (for example) 75-hp motor would require a 75 kva transformer. Transformers for small motors should have a somewhat larger kva capacity than the motor kva capacity if the motors are to be run at full load or slight overload most of the time.

TRANSFORMER POWER FACTOR

Power input to the primary coil of a transformer is practically equal to output—meaning that the power factor is close to 1.00. However, there may be small losses, in which case P will again equal, not the product of E times I, but the product of E times I times a power factor of less than 1.00.

In computing the load that a transformer can carry, you must determine the power factor and apply it to the product of E times I.

GROUNDING TRANSFORMERS

Grounding of a distribution system helps to prevent accidents to personnel and damage to property in the event of insulation breakdown, accidental shorting of high- and low-voltage lines, or a lightning strike.

If a high-voltage line is accidentally shorted with a low-voltage line, the current will flow through the secondary coil of the transformer to the secondary ground, which will in turn cause the primary protective device to open the circuit. In this case the primary protective device which functions is the substation circuit breaker. An accidental shorting of the primary and secondary windings in the transformer will cause the primary fuse, ahead of the transformer, to open.

If, however, there are no ground connections, the primary voltage will be impressed on the secondary conductors, which are usually insulated for 600 volts, and considerable damage to equipment will occur. Great danger will exist for anyone touching any electrical equipment at the time.

All metal noncurrent-carrying equipment of a substation must be grounded. All services must have the identified wire (white wire) grounded on the line side of the service switch. This ground may be inside or outside of the building at the point where the lines are fastened to the building.

If possible, the ground must be connected to a water pipe. If this is not possible, either a driven rod not less than 8 ft long and not less than 5/8 in. in diameter, or the metal frame of a building, plate electrode, or pipe electrode may be used. Electrode grounding is explained in article 250-54 of the National Electrical Code (NEC).

Individual transformer and lightning arrester grounds must not exceed 10 ohms.

If one electrode does not meet the specifications given, more must be installed until the resistance does not exceed specifications in 9Yi.

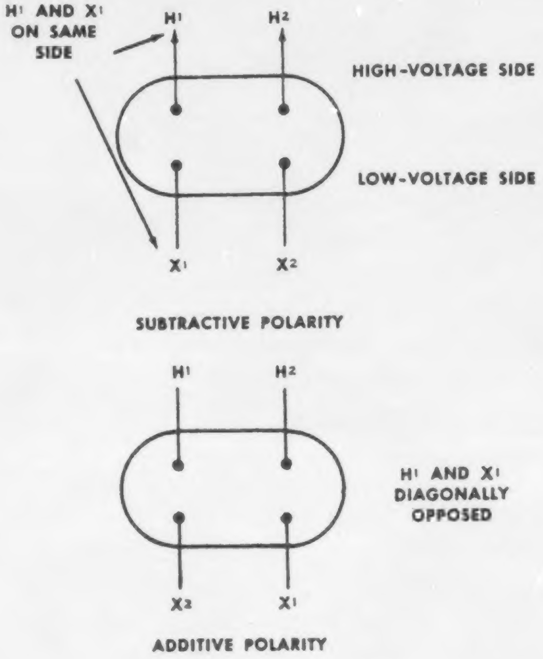
The grounding conductor shall be attached to the grounding electrode by an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron, or other equally substantial and approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections depending on solder must not be used. All grounding conductors shall be protected from mechanical injury by pipe or wooden molding.

TRANSFORMER POLARITY

All transformers carry standard polarity markings. The letter "H" is used to indicate the high-voltage terminals, and the letter "X" to indicate the secondary terminals. The extreme right-hand lead as you face the high-voltage side of the transformer is marked "H1," the next is marked "H2," and so on. The secondary terminals, "X1," "X2," and so on, may be in numerical order or reverse order.

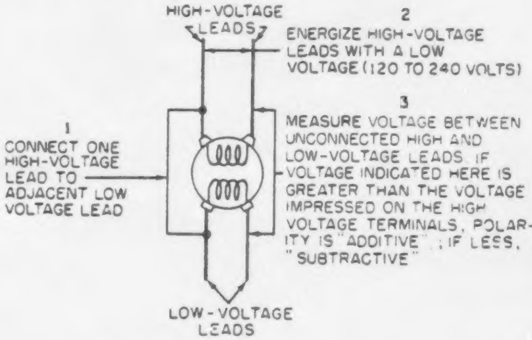
Transformer polarity is important only when transformers are connected in parallel for single-phase operation or are used to supply three-phase service. Figure 9-31 shows the lead markings of single-phase transformers with additive and subtractive polarity. Figure 9-32 shows how to test for polarity if the nameplate is missing.

CAUTION: When making such tests, voltage must not be applied across the secondary side of the transformer because the primary voltage would then be equal to the applied secondary voltage multiplied by the transformer turns ratio. This voltage would be dangerously high to personnel and damage the voltmeter.


H1 AND X1 ON SAME SIDE
H1
H2
HIGH-VOLTAGE SIDE
LOW-VOLTAGE SIDE
X1
X2
SUBTRACTIVE POLARITY
H1
H2
H1 AND X1 DIAGONALLY OPPOSED
X2
X1
ADDITIVE POLARITY

73.84

Figure 9-31.—Lead markings of single-phase transformer.


HIGH-VOLTAGE LEADS
2
ENERGIZE HIGH-VOLTAGE LEADS WITH A LOW VOLTAGE (120 TO 240 VOLTS)
1
CONNECT ONE HIGH-VOLTAGE LEAD TO ADJACENT LOW VOLTAGE LEAD
3
MEASURE VOLTAGE BETWEEN UNCONNECTED HIGH AND LOW-VOLTAGE LEADS. IF VOLTAGE INDICATED HERE IS GREATER THAN THE VOLTAGE IMPRESSED ON THE HIGH VOLTAGE TERMINALS, POLARITY IS "ADDITIVE"; IF LESS, "SUBTRACTIVE"
LOW-VOLTAGE LEADS

73.85

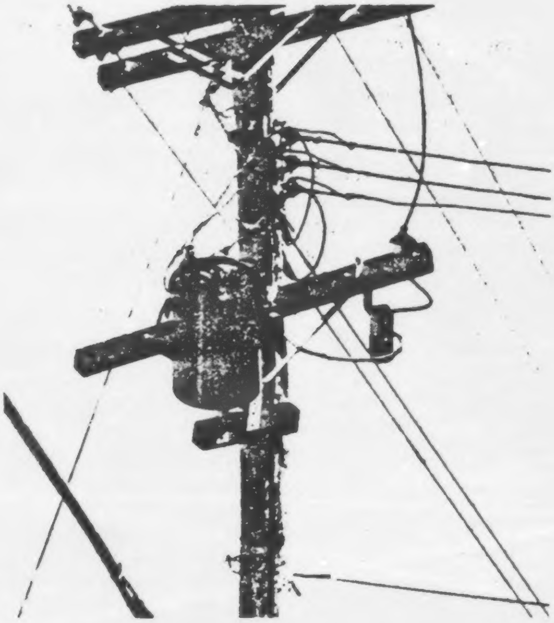
Figure 9-32.—Test for transformer polarity.

POLE-MOUNTED TRANSFORMERS

Transformers are mounted on poles in various ways, such as: suspended on a bracket bolted to the pole; suspended from a crossarm with brackets; or set on a platform mounted on an H-frame.

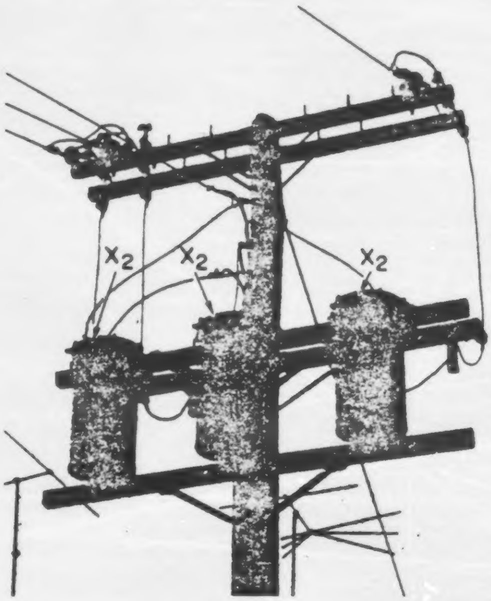
Single-phase transformers are usually hung with a through-bolt type bracket or a crossarm type bracket. Figure 9-33 shows a single transformer hung with crossarm brackets. Figure 9-34 shows a bank of three transformers of 25-kva capacity hung the same way.

Formerly, all banks of three transformers were hung with crossarm brackets or mounted on a platform between two poles. Recently, though, the transformer manufacturers have, because of improved materials, increased the



73.86

Figure 9-33.—Single transformer hung with crossarm brackets.



26.82(73)

Figure 9-34.—Three-phase bank of transformers hung on crossarm.

capacities of transformers without increasing their size and weight, so that banks of three large transformers can be hung on a pole by the use of the through-bolt bracket type of suspension, as shown in figure 9-35.

The old method of mounting transformers on a platform required an extra pole and the added cost of building the platform. Recently various power companies have adjudged the platform type mounting as obsolete, and are using the through-bolt method of hanging the transformers for the smaller transformers on all new construction. Figure 9-36 shows the platform method of mounting a bank of three single-phase, 25 kva transformers, Y-connected to obtain single-phase and three-phase power.

SUBSTATIONS

There are various types of substations, but only two, the "transmission" type and the "local" type, will be discussed here.

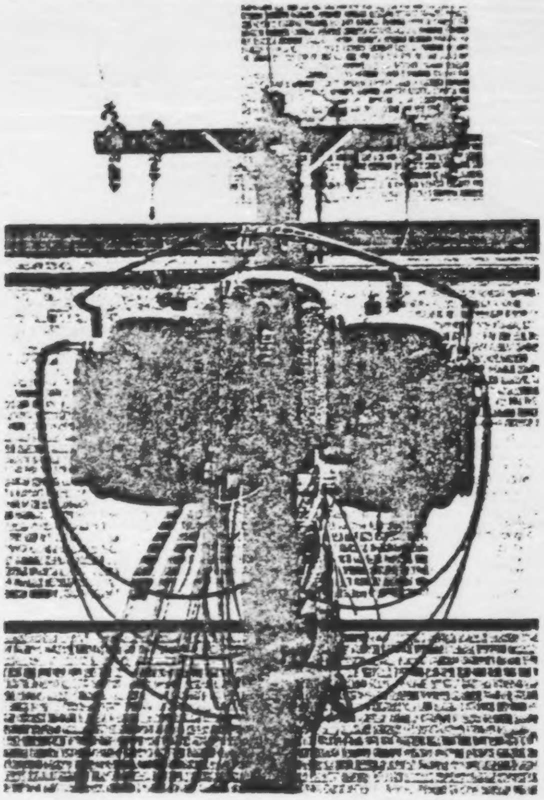
The transmission type of substation is usually installed where a high-voltage transmission line from a generating source of power enters a base or town—that is, at the point where high transmission voltage (which may range up to 110,000 kva) is to be reduced to lower distribution voltage (which is usually 2400 volts). This type of substation (see figure 9-37) is equipped with large metal-clad transformers of a high kva rating.

The local type of substation (fig. 9-38) is equipped with the regular tank-type transformer, but of a size too large for pole-mounting. This type of station reduces 2400-volt line voltage to 110/220-volt distribution-line voltage.

Both types of substations are mounted on a ground-level concrete slab. A "cyclone" type of wire fence surrounds the station to keep unauthorized personnel away from the transformer connections.

TRANSFORMER CONNECTIONS

Transformers are commonly connected for three-phase service by either "delta" connection or Y-connection (also called star connection).



73.88
Figure 9-35.—Three 37.5 kva transformers mounted with through-bolt type brackets.

Delta connection (fig. 9-39) is made by connecting adjacent terminals of the transformers. The right lead of one winding is connected to the left lead of the next winding. Coil voltage equals phase-to-phase voltage of the line. Coil current equals line current in each phase wire divided by 1.73.

Y-connection (fig. 9-40) is made by connecting the three right (or the three left) leads to a common neutral. The three left (or right) leads are connected to phase wires of the lines. Coil current equals line current in each phase wire. Thus, if three 2400-volt transformers are Y-connected to a circuit which measures 2400-volts from phase-to-neutral or 4160 volts from phase to phase, coil voltage is 2400 volts.

Three single-phase transformers connected to a three-phase circuit are called a transformer "bank." Connections are made with combinations of delta connections and Y-connections, some of which are as follows:

A bank of transformers is "delta-delta-connected" when the primary windings and the secondary windings are both connected in delta (fig. 9-41).

In an "open-delta" connection (fig. 9-42) one of the three transformers in a delta-delta bank is disconnected because of failure. This converts the delta-delta connection to an "open-delta" connection for emergency operation. The open-delta connection delivers three-phase power using only two single-phase transformers. The removal of one of the three transformers reduces the capacity of the bank, not to 66 2/3 percent of the original capacity as one might expect (100 percent minus 33 1/3 percent), but to 58 percent of the original capacity.

A bank of transformers is "Y-delta connected" when the three primary windings are Y-connected and the three secondary windings delta-connected (fig. 9-43). This permits the use of a primary voltage of 4160 volts with an output of 240 volts. Actually the primary voltage of each transformer is 2400 volts, as shown in figure 9-43.

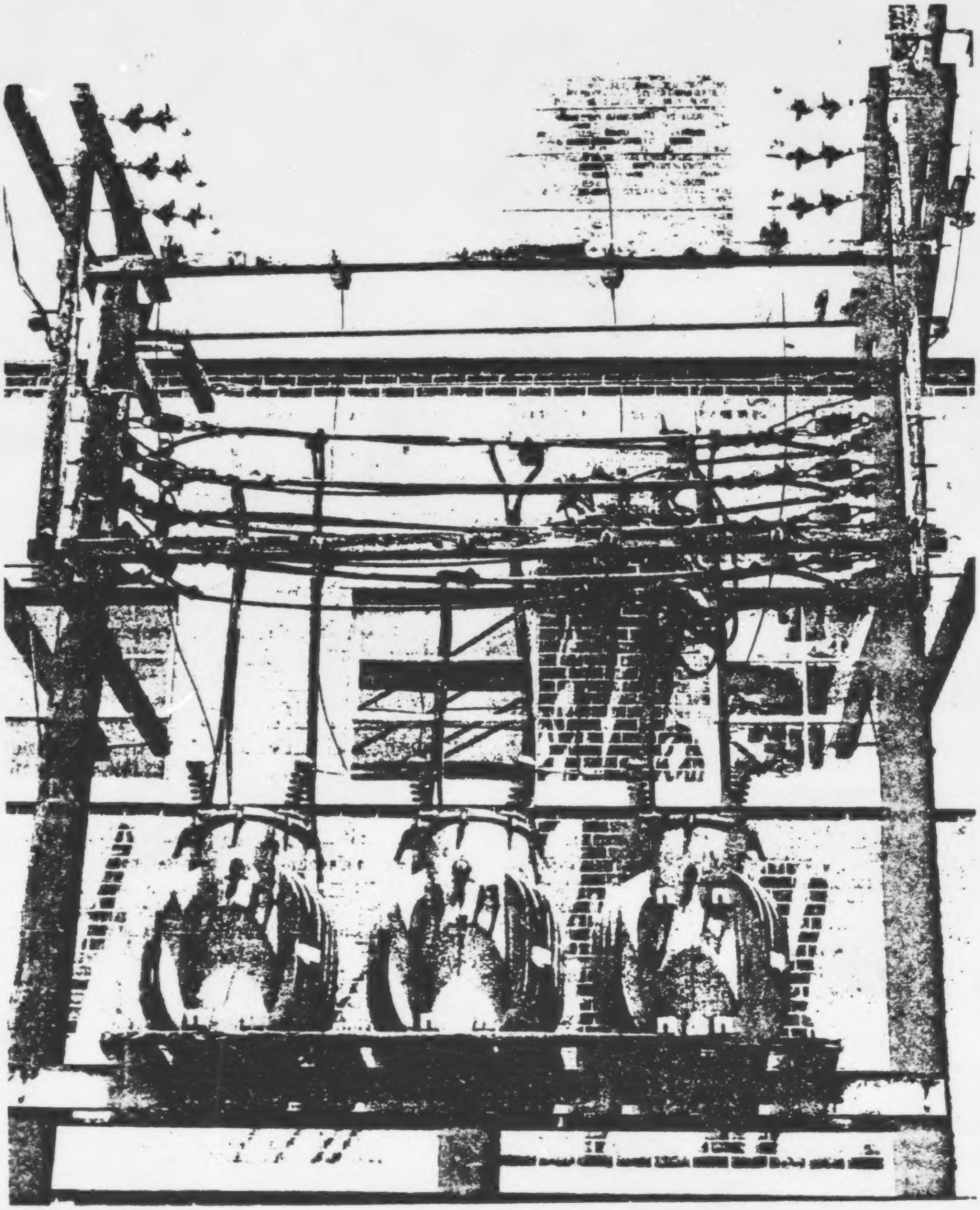
A bank of transformers is "delta-Y-connected" when the three primary windings are delta-connected and the three secondary windings Y-connected (fig. 9-44). By Y-connecting the secondary, you can take care of three-phase power and single-phase lighting from the same transformer bank. The single-phase load is evenly distributed by using the neutral wire and alternate lines. You can supply a 110-volt single-phase lighting system from a delta-delta connected bank of transformers by grounding the midtap of one of the transformers; however, this has the disadvantage that it puts the entire lighting load on one transformer.

A bank of transformers is "Y-Y-connected" (fig. 9-45) when both primary and secondary windings are Y-connected. Because the arrangement is one which causes inductive disturbances, it is seldom used.

PROTECTIVE DEVICES

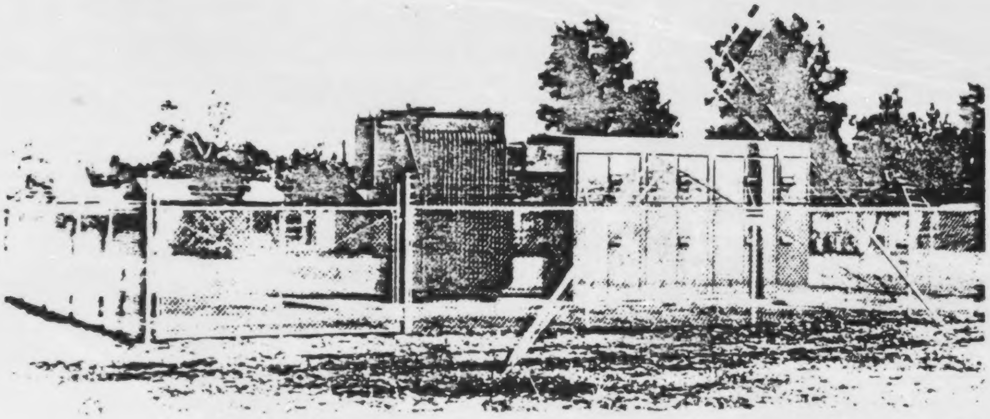
Circuit protective devices are divided into two main categories: primary devices and secondary devices. The primary devices protect the high-voltage transmission lines, the transformer installations, and the substations. The secondary devices protect the electrical

918



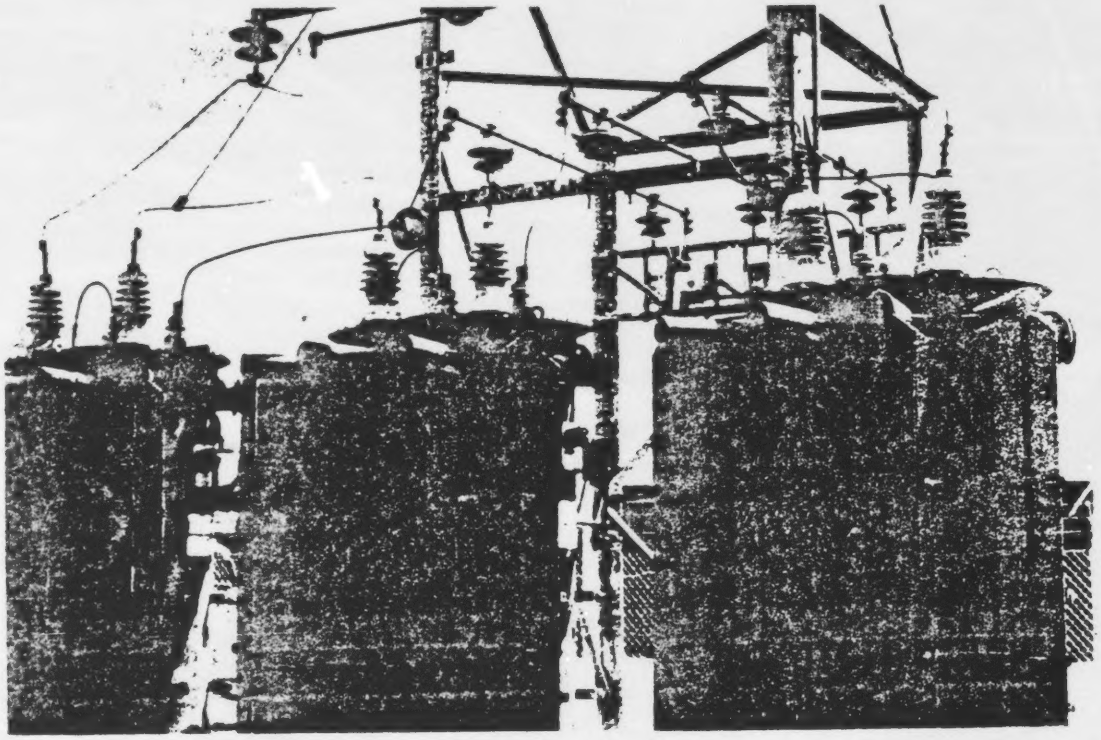
65.62

Figure 9-36.—Three single-phase 25-kva transformers mounted on H-frame platform.



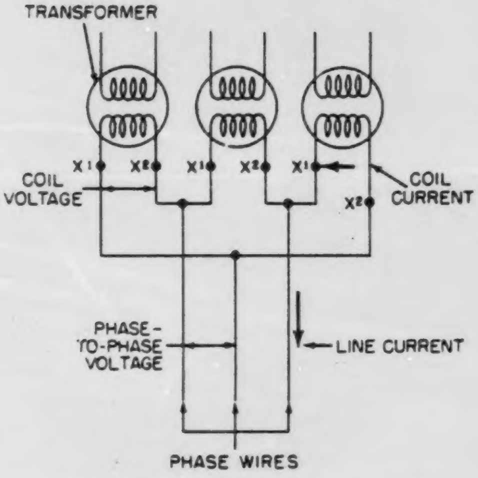
73.90

Figure 9-37.—Transmission-type substation with high-voltage switchgear.



73.91

Figure 9-38.—Local type of substation.


TRANSFORMER
X1
X2
X1
X2
X1
X2
COIL VOLTAGE
COIL CURRENT
PHASE-TO-PHASE VOLTAGE
LINE CURRENT
PHASE WIRES

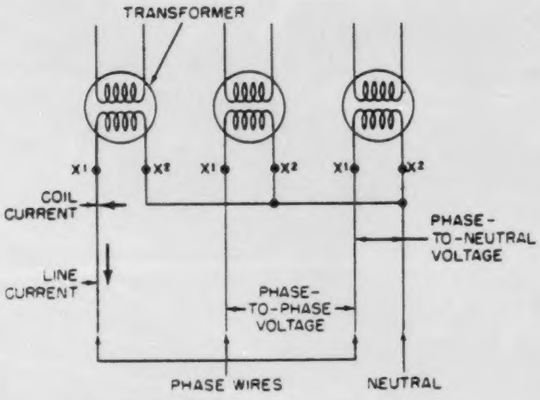
FOR DELTA CONNECTION

COIL VOLTAGE = PHASE-TO-PHASE VOLTAGE

$$\text{COIL CURRENT} = \frac{\text{LINE CURRENT}}{1.73}$$

73.92

Figure 9-39.—Delta connection.


TRANSFORMER
X1
X2
X1
X2
X1
X2
COIL CURRENT
LINE CURRENT
PHASE-TO-NEUTRAL VOLTAGE
PHASE-TO-PHASE VOLTAGE
PHASE WIRES
NEUTRAL

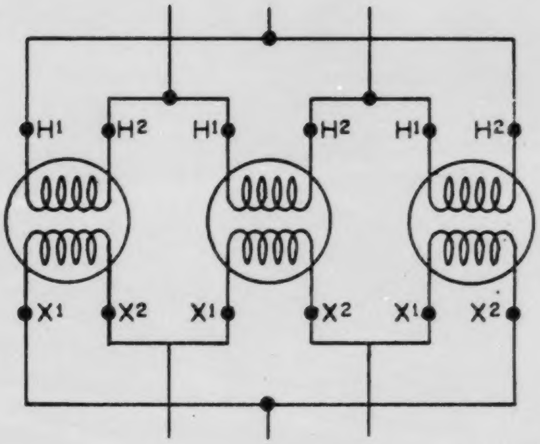
FOR T-CONNECTION

COIL VOLTAGE = PHASE-TO-NEUTRAL VOLTAGE

COIL CURRENT = LINE CURRENT

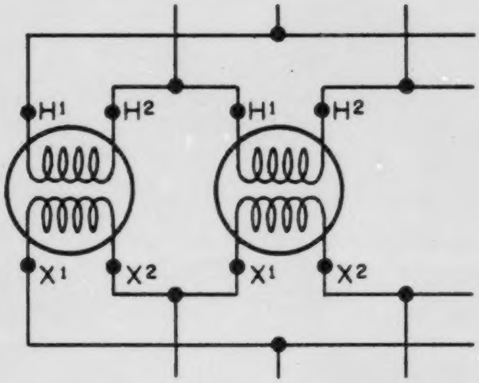
73.93

Figure 9-40.—Y connection.


H1
H2
H1
H2
H1
H2
X1
X2
X1
X2
X1
X2

73.94

Figure 9-41.—Delta-delta connection.


H1
H2
H1
H2
X1
X2
X1
X2

73.95

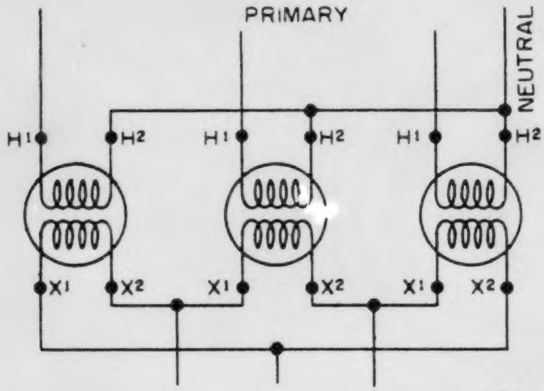
Figure 9-42.—Open-delta connection.

equipment on the secondary side of the transformers—that is, the lighting circuits, motors, and other appliances which are the final consumers of power.

PRIMARY DEVICES

The primary protective devices consist of fused disconnect switches, circuit breakers, lightning arresters, and grounds.

Disconnect switches used in transmission lines are not, strictly speaking, true protective devices, because they are used for isolating



73.96

Figure 9-43.—Y-delta connection.

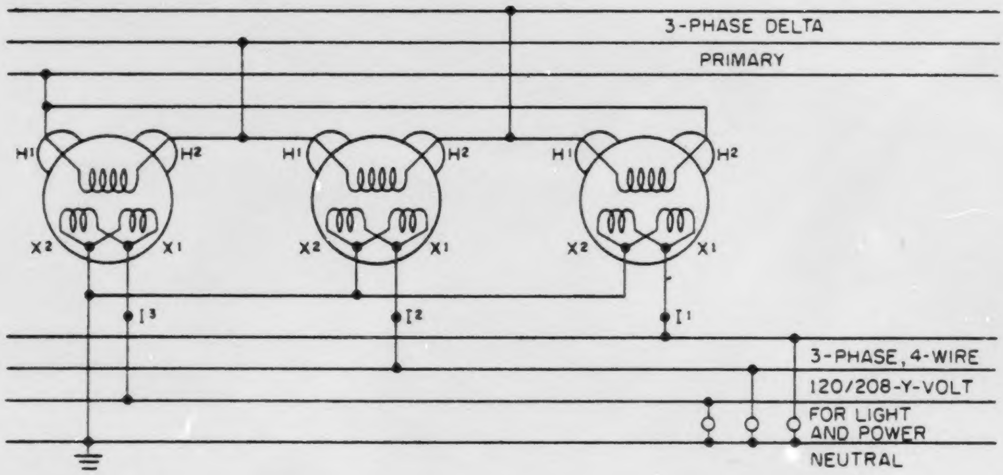
only certain parts of the line. By opening a disconnect switch, linemen can cut a line off from the main line or circuit, for repair work, without deenergizing the complete circuit.

This type of switch is made for single-pole or gang operation. Although it may be motor-operated, it is more commonly operated by hand on the ground, by throwing a switch handle. Both handle and rod must be grounded. A handle-to-the-ground operated gang disconnect switch must also have some means of locking the switch in ON or OFF position, to prevent operation by unauthorized person.

Figure 9-46 shows a single-pole hook-operated disconnect switch. Figure 9-47 shows a pole-top disconnect switch.

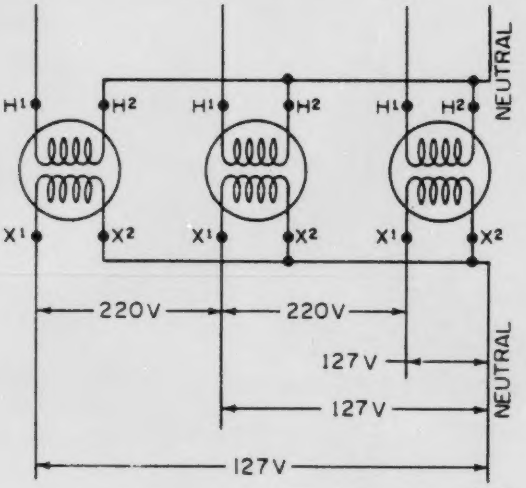
Primary cutouts or fused disconnect switches are placed ahead of transformers, in the primary feeder, to open the circuit should the transformer become overloaded to a dangerous point. They are also used to isolate the transformer in order to make repairs or changes on the secondary line. Figure 9-48 shows a 100-ampere 7500-volt fuse disconnect equipped with a standard fuse holder and fuse link. By substituting the switch blade (shown at left of cutout) for the fuse holder, the cutout can be used as a straight disconnect switch. The switch blade has a 200-ampere carrying capacity. Figure 9-49 shows open-type fused disconnect switches. Disconnect switches are generally used in the primary circuit when opening the circuit is necessary under voltage but with little or no load current.

Oil circuit breakers, mentioned in a previous chapter, are used in circuits carrying more than 600 volts. One of these can be used to open a circuit automatically upon overload. They are generally designed and connected for one or more automatic reclosings, thus restoring service rapidly when a fault has cleared itself. Oil switches are, therefore, used where control of a high-current circuit as well as protection from overload and short circuit are desired.



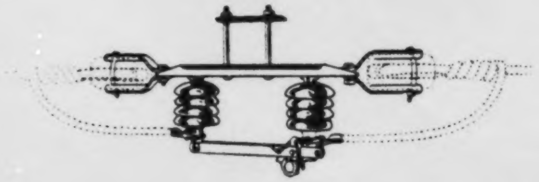
26.87(73)

Figure 9-44.—Delta-Y connection.



73.98

Figure 9-45.—Y-Y connection.



73.99

Figure 9-46.—Single-pole hook-type disconnect switch.

Some transformers are protected against excessive voltages and overload by lightning arresters and circuit breakers which are integral parts of the transformer (see fig. 9-50). A heavy overload on the secondary circuit opens a breaker inside the tank, disconnecting the transformer from the load. Overloads not large enough to damage the transformer cause an indicating light on the outside of the tank to turn on. The glowing light indicates that the load is too large. Unless the overload is only temporary, the transformer must be replaced by one of larger capacity, or some of the load must be transferred to a different transformer.

LIGHTNING ARRESTERS

A lightning arrester protects a line against the very high voltages which occur when lightning strikes. When the voltage rise above normal occurs, an arc forms across a horn-gap in the arrester and the overload passes from the horn-gap to ground through the ground wire or other grounding device. When the excessive-voltage interval has passed (immediately after the lightning has struck), the action of the arrester prevents flow of normal current.

73.100

Figure 9-47.—Pole-top disconnect switch.

Various types of lightning arresters are shown in figure 9-51.

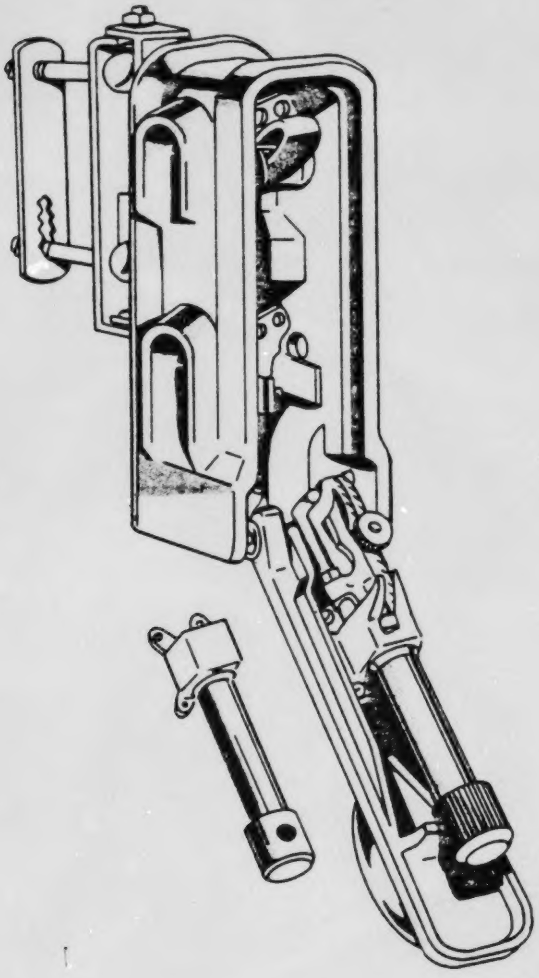
Table 9-3 is a troubleshooter's guide to be used in determining maintenance procedure for oxide-film arresters.

OIL CIRCUIT BREAKER TROUBLESHOOTING

Table 9-4 should be helpful as a guide for the maintenance of oil circuit breakers.

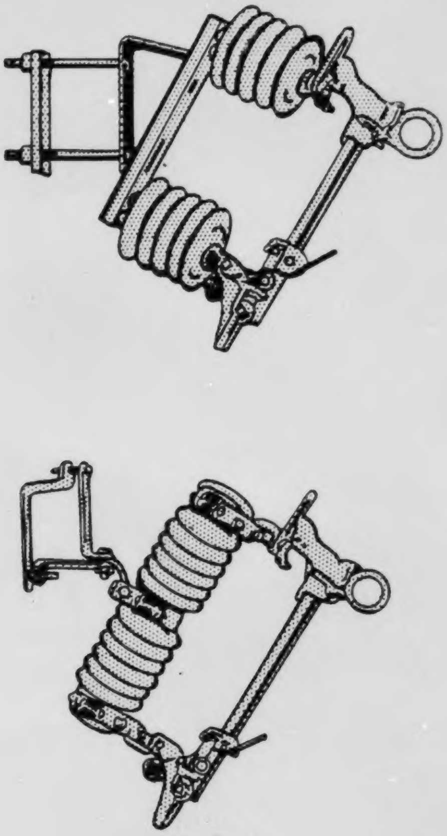
EXTERIOR LIGHTING

A "series" outdoor lighting circuit (fig. 9-52) is supplied by a regulating transformer which gives a uniform current usually of 6.6 amperes to the street lights in the circuit. Insulating



73.101

Figure 9-48.—Fused cutout and disconnect blade.



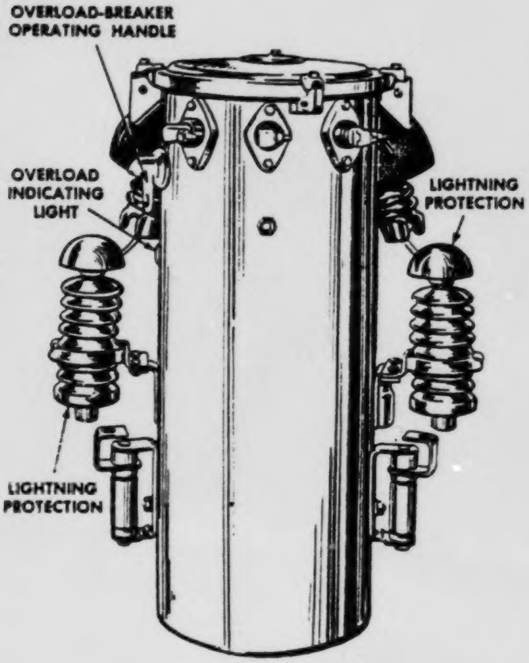
73.102

Figure 9-49.—Open-type fused disconnect switches.

transformers or autotransformers are available for stepping up the current to 15 or 20 amperes. The higher amperage permits more rugged lamp filaments, which give longer life for lamps of equal candlepower and higher lamp efficiency. The series circuit is easily controlled, but any break interrupts the entire circuit. Film-disk cutouts in the lamp socket (fig. 9-53) prevent lamp failures from interrupting the circuit.

With the lamp operating, the current passes from one finger through the lamp and out the other finger. When a lamp fails the film-disk insulation punctures, allowing the current to pass from one finger through the punctured film disk to the other without going into the lamp. The center terminal is mounted so the fingers are shorted when the lamp is removed, preventing the circuit from being opened. CAUTION: Do not re-use punctured film disk cutouts or substitute tape or paper for a film disk cutout.

A "multiple" circuit consists of a number of street lights supplied by a distribution transformer delivering a constant low voltage to a circuit or a secondary main which also supplies other loads. However, running secondary conductors any great distance to supply a lamp or group of lamps is impractical be-



73.103
Figure 9-50.—Self-protected transformer.

cause of the excessive voltage drop. The cost of the multiple luminaire (the term "luminaire" is applied collectively to a light and its attendant reflectors and other accessories) is low compared to the series type, because of the low voltage; but this saving is largely offset by increased control devices and increased copper-wire size.

INSTALLING LIGHTING CIRCUITS

A series circuit may be installed with the return wire on the same pole or it may follow a different route. These are known as closed loop and open loop circuits (fig. 9-54). A series circuit may be installed on the same crossarm with the primary-distribution conductors (fig. 9-55). If two primary crossarms are necessary, the street-light wires should be carried on the lower arm in the end-pin position. If two separate single-conductor street circuits are on the same lead, they should not be placed in adjacent pin positions because it would cause confusion in troubleshooting.

INSULATORS

Insulators should be based on the open-circuit voltage of the largest regulator (see later), and are usually the same size as those used for primary distribution.

CONDUCTOR SIZE

Conductor size should be No. 6 medium hard-drawn copper or its mechanical equivalent. Sag should be the same as for primary distribution.

REGULATORS AND CONTROLS

Constant-Current Regulators

The constant-current regulator is a transformer with a movable secondary winding that positions itself to provide constant current for any load within its full-load rating. For series street lamps, the current must be held close to the current rating of the lamp, because higher currents reduce lamp life and lower currents reduce light output.

PRIMARY OIL SWITCHES

The switch for energizing street-light regulators should operate in oil, because it must break the primary current of a regulator at least once each day. If manual control switches are used, someone must be on duty when switches are turned on and off. Ordinarily, the street circuits should be turned on one half-hour before sunrise.

TIME SWITCHES

A time switch is a clock-driven mechanism which can be set to turn street circuits on and off automatically. A time switch should have a weatherproof case if mounted outdoors. In climates where the temperature goes lower than 10°F, a heating unit must be included or the time clock must be placed indoors. Ordinarily a 40-watt resistor connected across the line side furnishes enough heat.

There are other types of automatic switches, including the photoelectric relay, which turns on lighting circuits when the natural illumination falls below a given level.

Table 9-3.—Oxide-film arrester maintenance schedule.

Trouble	Probable Cause	Remedy
Tracing or corona marks on surface of wood clamping posts.	Undue leakage of power current over surface of clamping post caused by accumulation of semiconducting dirt or foreign matter.	Disassemble cell stock. Clean and refinish posts. Reassemble.
Flashover of wood clamping posts.	Accumulated semiconducting dirt or foreign material on clamping posts.	Replacement of clamping posts usually necessary. If cells are badly burned, replace them.
Arcing or corona discharges from gap assembly or cell-stack assembly.	Loose or broken connections.	Tighten or repair connections.
	Insufficient clamping pressure on cells or improper centering of cells on clamping plates.	Adjust clamping plates to press cell stack securely in position.
	Incorrect gap.	Set gap in accordance with instructions.

73.321

EXTERIOR LIGHTING FIXTURES

A street-lighting fixture includes the mounting bracket or post as well as the luminaire itself. The mounting bracket for an overhead light usually consists of a metal pipe or frame work with a pole-mounting fitting at one end and a luminaire at the other (fig. 9-56). An "upsweep bracket" type of fixture is shown in figure 9-57. A "straight-bracket" fixture is shown in figure 9-58.

Positioning the lamp at or near the center of the street (called center-span installation, fig. 9-59) gives the most satisfactory street lighting and is preferred.

To prevent any possibility of fragmented glass from entering your eye, wherever possible, keep your eye level above that of the lamp when replacing a defective lamp.

OBSTRUCTION LIGHTING

Obstruction lights are used to indicate the existence of obstructions. These lights are aviation red in color, with an intensity of not less than 10 candlepower. The number and arrangement of lights at each level to be lighted should be such that the obstruction is indicated from every angle of azimuth. Figures 9-60 through 62 illustrate these methods of lighting.

Vertical Arrangement

At least two lamps, either operating simultaneously or circuited so that upon failure of one, another becomes operative, will be located at the top of the obstruction. An exception is made in the case of a chimney or similar structure, on which the top lights are to be placed between 5 and 10 feet below the top. Where the top of the obstruction is more than 150 feet above the level of the surrounding ground, an intermediate light or lights will be provided for each additional 150 feet, or fraction thereof. These intermediate lights will be spaced as equally as practicable between the top light, or lights, and the ground level.

926

Table 9-4.—Oil circuit breaker troubleshooting.

Trouble	Probable Cause	Remedy
Switch overheats under normal continuous service.	Overload	Reduce load or increase capacity of circuit breaker.
	High resistance contact resulting from burns.	Dress up contacts properly and adjust to correct tension.
	Not enough tension on contact springs.	If contacts are not burned, increase tension on contact springs.
	Oxide deposit on contact block.	Dress contact block with fine sandpaper.
	Oil deteriorated.	Replace oil in tanks.
	Poor contact on bushing.	Remove and dress up connecting lugs, terminals, and the like.
	Leads to bushing terminals too small.	Increase size of leads.
	Poor ventilation.	Improve ventilation.
Tanks bulged, oil thrown out through breather, and the like from force of explosion.	Switch opening too slow or did not open all the way to clear the arc.	Adjust switch to proper opening speed. See that it opens all the way and does not rebound to reestablish arc.
	Severe arc caused by switch opening under short circuit.	Overhaul switch. Change or renovate oil. Repair damage. Remove primary cause of trouble.
	Short or ground caused by lightning.	Check lightning arresters and repair or replace as necessary.
	Bushing failure inside switch or failure of wood member causing phase to ground short inside tank.	Replace bushing or wood member. Repair damage.
Smoking at breathers, mechanism openings, and so on while switch is in service.	Arcing at contacts or across wood members below oil line ignites liners or wood members. Leakage across wood members may be caused by water or carbon in the oil or dampness in wood.	Remove oil switch from circuit at once. Locate source of trouble. Check condition of oil, wood members, contacts, liners, and baffles in tank.

73.320.1

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Table 9-4.—Oil circuit breaker troubleshooting—(continued).

Trouble	Probable Cause	Remedy
Switch overtravels in closing.	Broken or weak buffer springs.	Replace buffer springs.
	Bell crank mechanism traveling too far over center.	Adjust bell crank linkage.
	Mechanism stops not properly adjusted.	Set stops on mechanism as indicated by hand operation of switch.
	Broken trip spring.	Replace trip spring and adjust properly.
Switch rebounds and partially recloses after being tripped out.	Empty dash pots.	Clean and refill dash pots.
	Dash pots not adjusted properly.	Adjust dash pot travel.
	Broken bumper spring.	Replace bumper spring.
	Overtension on balance spring.	Adjust balance spring tension.

73.320.2

Horizontal Arrangement

Obstructions consisting of built-up and tree-covered areas are examples of extensive obstructions. Where an extensive obstruction or a group of closely spaced obstructions is marked with obstruction lights, the top lights will be displayed on the point or edge of the obstruction highest in relation to the obstruction marking surface, at intervals of not more than 150 feet, so as to indicate the general definition and extent on the obstruction. If two or more edges of an obstruction located near an airfield are at the same height, the edge nearest the airfield will be lighted.

Lighting of Overhead Wires

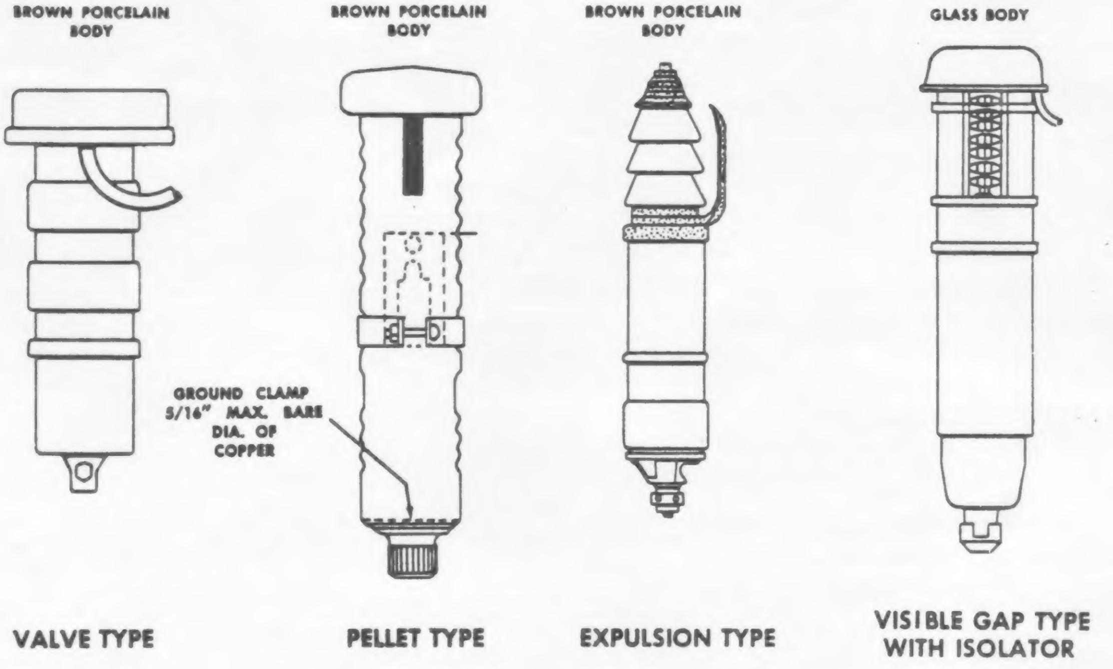
When obstruction lighting of overhead wires is needed, the lights will be placed not more than 150 feet apart at a level not below that of the highest wire at each point lighted. When the overhead wires are located more than 150,000 feet from the center of the landing area, the distance between lights may be increased to no more than 600 feet.

OVERHEAD SYSTEM SAFETY

PROTECTIVE CLOTHING AND EQUIPMENT

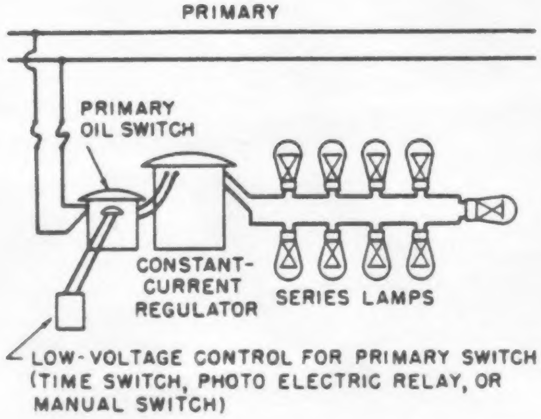
A lineman should always wear gloves if he is tending a reel for stringing conductors. Never work with the gauntlets of the gloves turned down.

Do not wear hobnailed shoes or shoes with metal plates. When trimming trees for pole lines, wear rubbers or rubber-soled shoes for climbing. Always test safety strap and body belt before using them. Never wear a strap with stitching across it, or one mended with tape. Make all the safety checks of climbing equipment previously mentioned in this chapter every time you prepare to go aloft.


BROWN PORCELAIN BODY
BROWN PORCELAIN BODY
BROWN PORCELAIN BODY
GLASS BODY
GROUND CLAMP 5/16" MAX. BARE DIA. OF COPPER
VALVE TYPE
PELLET TYPE
EXPULSION TYPE
VISIBLE GAP TYPE WITH ISOLATOR

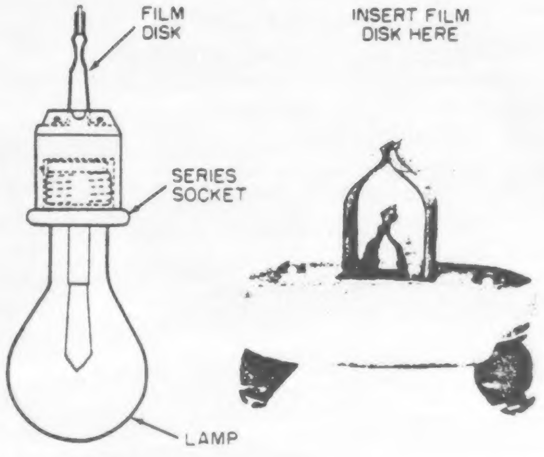
73.104

Figure 9-51.—Types of lightning arresters.


PRIMARY
PRIMARY OIL SWITCH
CONSTANT-CURRENT REGULATOR
SERIES LAMPS
LOW-VOLTAGE CONTROL FOR PRIMARY SWITCH (TIME SWITCH, PHOTO ELECTRIC RELAY, OR MANUAL SWITCH)

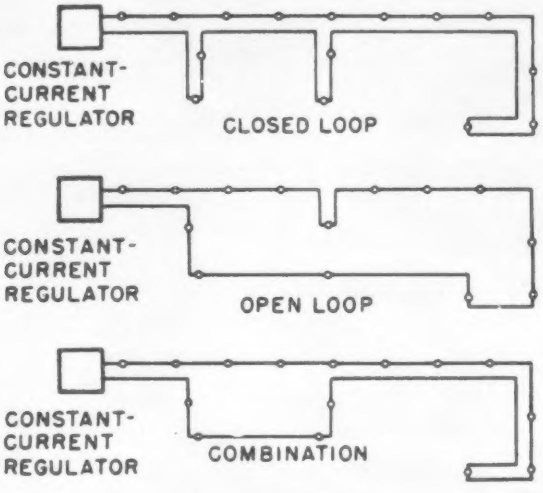
73.262

Figure 9-52.—Series street-lighting circuit.


FILM DISK
INSERT FILM DISK HERE
SERIES SOCKET
LAMP

73.322

Figure 9-53.—Series lamp, socket, and film disk.


CONSTANT-
CURRENT
REGULATOR
CLOSED LOOP
CONSTANT-
CURRENT
REGULATOR
OPEN LOOP
CONSTANT-
CURRENT
REGULATOR
COMBINATION

73.263
Figure 9-54.—Closed and open loops in series circuits.

SAFETY IN POLE-RAISING

As a pole is being raised, it is safest to assume that at any moment something may slip or break. Stand as far away from the pole as possible if you are not in the raising crew.

The pike-pole method of setting poles should not be used unless there are enough men to do the work safely. In using pikes, the men must stand far enough apart so that they will not interfere with each other. Never brace a pike pole on your stomach. If the pole shifted your way, you would not be able to get clear.

SAFETY IN POLE CLIMBING

Never climb an erected pole until it has been plumbed, backfilled, and tamped. Before going aloft, make sure the pole can stand your weight, and make the previously described careful inspection of body belt, safety strap, and climbers.

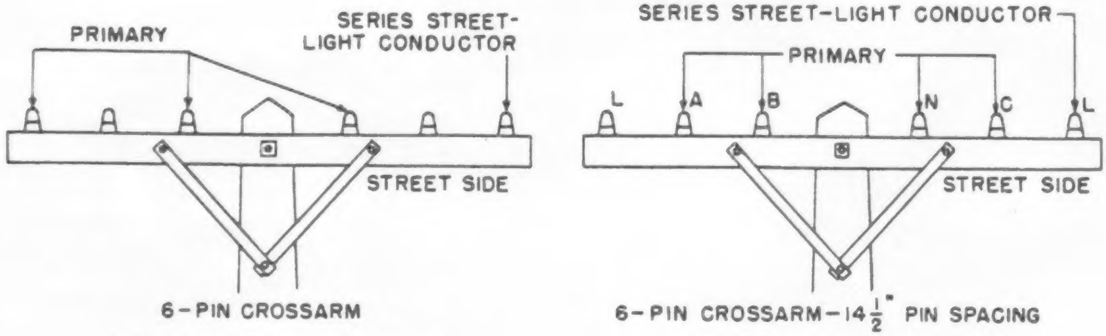
The body belt contains pockets for small tools. It is important to keep the tools in these pockets. Never use the center loop on the body belt for carrying a tool, however. In case of a fall, the tool may injure your tail bone.

If you try to climb with tools in your hands, your own balance on the pole will be unsafe, and you could drop tools on someone below.

The safety strap is used to secure you to the pole, leaving your hands free to work. As you go up it is always fastened to a single D-ring on the body belt. For a right-handed man it is carried on the left D-ring.

Never use an improvised safety strap, or one that has been lengthened by the addition of rope or wire. Never attach the strap to pins or to crossarm braces. Never put the safety strap around the pole above the highest crossarm if the length of pole above the crossarm is short. The strap should never be less than 1 foot below top of the pole.

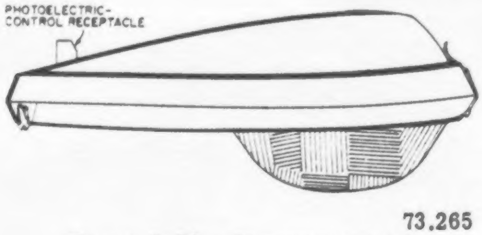
Never wear climbers except when climbing or about to climb. Be careful not to gaff


PRIMARY
SERIES STREET-LIGHT CONDUCTOR
STREET SIDE
6-PIN CROSSARM
SERIES STREET-LIGHT CONDUCTOR
PRIMARY
L
A
B
N
C
L
STREET SIDE
6-PIN CROSSARM—14½" PIN SPACING

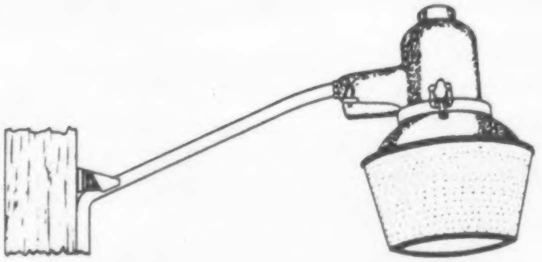
SERIES STREET CIRCUIT ON ARM WITH DELTA PRIMARY

SERIES STREET CIRCUIT ON ARM WITH WYE PRIMARY

73.264
Figure 9-55.—Series circuit on same crossarm with primary distribution system.

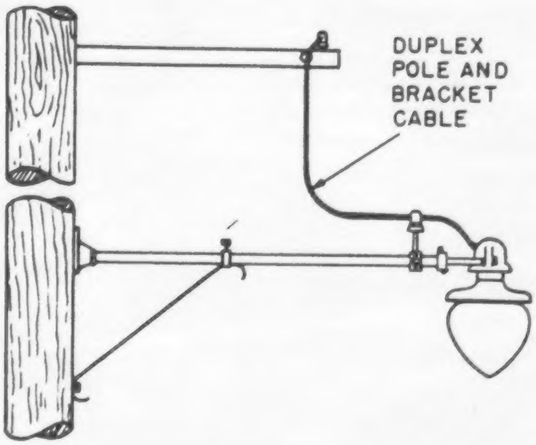

PHOTOELECTRIC-
CONTROL RECEPTACLE

73.265
Figure 9-56.—Common type of exterior lighting fixture.



73.266
Figure 9-57.—Upsweep-bracket fixture.

yourself or anybody else. Never wear climbers while riding in a truck.

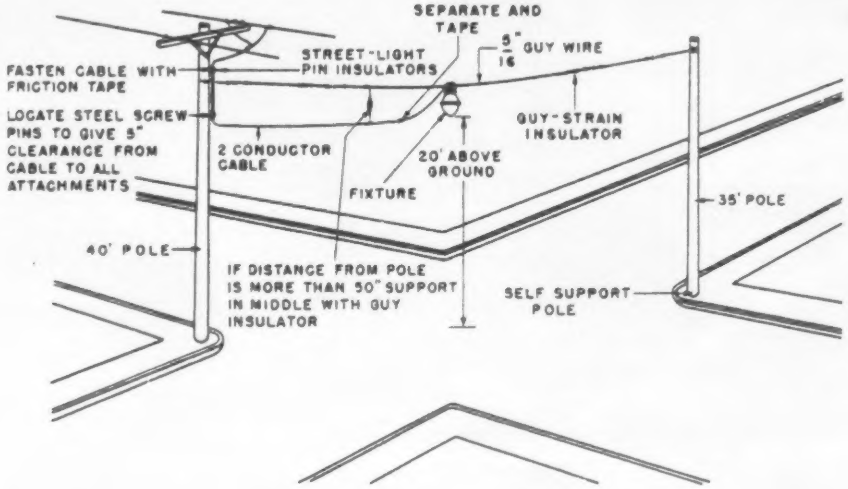

DUPLEX
POLE AND
BRACKET
CABLE

73.267
Figure 9-58.—Straight-bracket fixture.

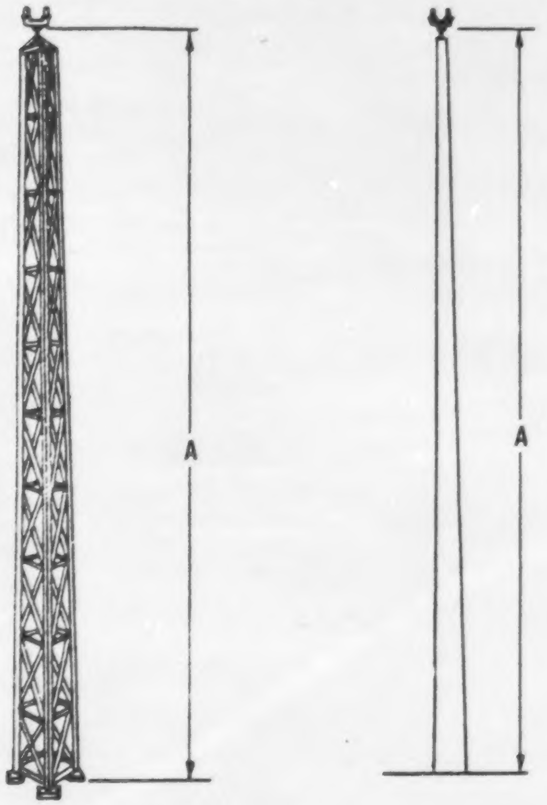
POLE-TOP RESUSCITATION

When a man working aloft is shocked into unconsciousness, there are several ways of performing "pole-top resuscitation," depending on the prevailing circumstances.

If the victim has not received severe face or nose injuries, the mouth-to-mouth method


SEPARATE AND TAPE
STREET-LIGHT PIN INSULATORS
5/16" GUY WIRE
FASTEN CABLE WITH FRICTION TAPE
LOCATE STEEL SCREW PINS TO GIVE 5" CLEARANCE FROM CABLE TO ALL ATTACHMENTS
2 CONDUCTOR CABLE
GUY-STRAIN INSULATOR
20' ABOVE GROUND
FIXTURE
35' POLE
40' POLE
IF DISTANCE FROM POLE IS MORE THAN 50" SUPPORT IN MIDDLE WITH GUY INSULATOR
SELF SUPPORT POLE

73.268
Figure 9-59.—Center-span installation.



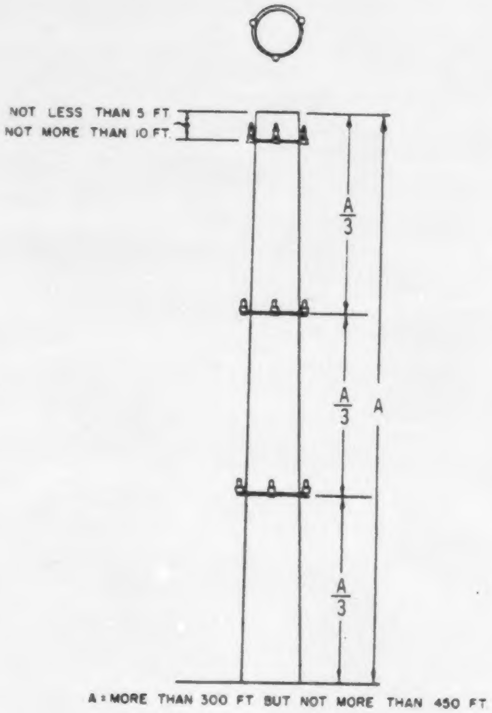
A = NOT MORE THAN 150 FT.

NOTE:

WHERE "A" EXCEEDS 150FT. INTERMEDIATE LIGHTS WILL BE REQUIRED FOR EACH ADDITIONAL 150FT. OR FRACTION THEREOF.

73.323

Figure 9-60.—Lighting of towers, poles and similar obstructions



73.324

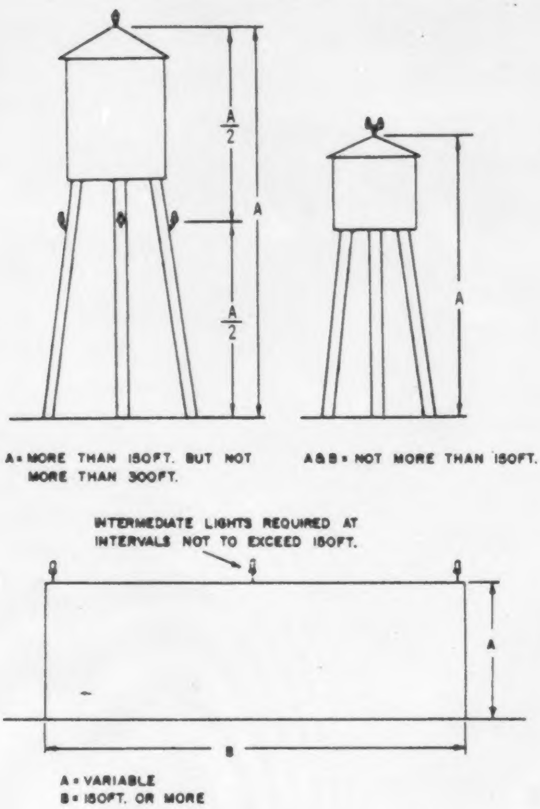
Figure 9-61.—Lighting of smokestacks and similar obstructions.

described should be given in preference to other pole-top methods, because it is easier to apply, can be started more quickly, is more effective, and can be given for a longer period of time without tiring the operator. The same rule apply for this method on a pole as for on the ground.

If the mouth-to-mouth method cannot be used, the next-best alternative is the Oesterreich pole-top method. This is administered as follows. First free the victim from electrical contact, making careful use of rubber insulating equipment. Then, if possible, maneuver him into vertical position and remove his climbers.

Next take a position on the pole just below the victim's feet, and with your safety belt around the pole, climb behind the victim with your safety strap between his legs. When the strap is as high between the legs as you can get it, hold the victim in straddle position on the strap as shown in figure 9-63A.

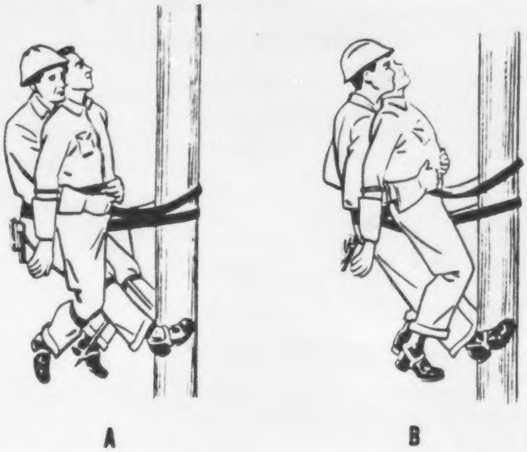
Next clear the victim's mouth of any obstructions and/or foreign matter and tilt the head back to clear the air passage. Then encircle the waist of the victim with your arms, and place both hands on his abdomen, with thumbs below the ribs and fingers touching, as shown in figure 9-63B. With your arms and hands, compress the abdomen with an upward squeezing motion. At the finish of this motion, cup your hands with the fingers depressing the abdomen just below the breast-bone. Repeat


A/2
A
A/2
A
A = MORE THAN 150FT. BUT NOT MORE THAN 300FT.
A&B = NOT MORE THAN 150FT.
INTERMEDIATE LIGHTS REQUIRED AT INTERVALS NOT TO EXCEED 150FT.
A
B
A = VARIABLE
B = 150FT. OR MORE

73.325

Figure 9-62.—Lighting of water towers and similar obstructions.

this process of squeeze, pressure, and release about 12 times a minute. If the victim begins to breath, take care to keep him under control while the violent motion which usually accompanies recovering consciousness is occurring.



4.227(73)

Figure 9-63.—Oesterreich method of pole-top resuscitation.

If you are the only other person (besides the victim) at the scene, inch yourself and the victim down the pole as you apply the resuscitation. After you complete each stroke, lean forward to slacken the safety belt (while still holding the victim on it) and move downward, even if you can only make an inch or two.

It others are available on the ground, have a line passed up and secure it to yourself and the victim so that the personnel on the ground can lower you both as you give the artificial respiration.

After a victim has revived, keep him as quiet as possible until he is breathing regularly. Have him lying down, of course. Keep him well covered and under constant close observation. Do not allow him to sit up, walk, or move until he is under regular medical care.